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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CXV.—No. 2985.] *LONDON: FRIDAY, MARCH* 16, 1923. [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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Steam Road Rollers & Tractors.

A. G. Mumford, Ltd. CULVER STREET WORKS, COLCHESTER. ON ADMIRALTY AND WAR OFFICE LISTS. ENGINES for Torpedo Boats, Yachts, Launches, BOILER FEED PUMPS. See Advertisement, pages 25 and 37, last week. PATENT WATER-TUBE BOILERS, AUTOMATIC FEED REGULATORS, And Auxiliary Machinery as supplied to the Admiralty. 2179

For Sale, at Low Prices. Three 60 inch Water-driven Hydro EXTRACTORS by Watson, Laidlaw & Co., Ltd.; new condition. JOHN H. RIDDEL, LTD., 40, St. Enoch Square, Glasgow.

For Sale, Selections from Stock at Reduced Prices. Numerous AIR COMPRESSORS, Belt and Steam driven, from 10 ft. up to 2178 cubic feet. MACHINE TOOLS of every Description. Shipyard Plant and Equipment a Specialty. IF IT'S MACHINERY, SEND US YOUR ENQUIRIES. JOHN H. RIDDEL, LTD., 40, St. Enoch Square, Glasgow. Established 1876. 592

SPECIFY WELDLESS STEEL CHAIN. The Strongest Chain IN THE WORLD. 898 Sole Manufacturers: WELDLESS CHAINS, LTD., 50, WELLINGTON STREET, GLASGOW.

Tank Locomotives. Specification and Workmanship equal to Main Line Locomotives. R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 1133

Spencer-Hopwood & Kirke PATENT BOILERS. *See page* 82, *March* 9. 1293 Sole Makers: SPENCER BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

Æ Tubes, Plates, Rods, &c., in Brass and Copper. ALLEN EVERITT & SONS, LTD., Kingston Metal Works, SMETHWICK, BIRMINGHAM. 1344

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Steam Hammers (with or without guides). Hand-worked or self-acting TOOLS for SHIPBUILDERS & BOILERMAKERS. 1159 DAVISAIRMROSE, LIMITED, LEITH, EDINBURGH.

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Bever, Dorling & Co., Ltd., BRADFORD. HIGH-CLASS ENGINES FOR ALL PURPOSES, also WINDING, HAULING, AIR COMPRESSING and PUMPING ENGINES. 1896

Cranes.—Electric, Steam, HYDRAULIC and HAND, of all types and sizes. GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 1137

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YARROW & CO. (1922), LTD., GLASGOW. PASSENGER AND CARGO STEAMERS, SHALLOW DRAFT VESSELS. 818

Campbells & Hunter, Ltd. SPECIALISTS IN Drillers & Boring Machinery for Engine Works and Boiler Shops. DOLPHIN FOUNDRY, LEEDS. 4547

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Cochran MULTITUBULAR AND CROSS-TUBE TYPES Boilers. See page 17, March 9. 1134

The Mitchell Conveyor and TRANSPORTER CO., LTD., CONTRACTING ENGINEERS. DESIGNERS and BUILDERS of all Classes of HANDLING MACHINERY. Atlantic House, 45-50, Holborn Viaduct, London, E.C. 1. Telegrams: "Micontrace, Cent, London." Telephone: Holborn 2822. 967

The Glasgow Railway Engineering Company, GOVAN, GLASGOW. LTD. London Office—12, Victoria Street, S.W. MANUFACTURERS OF RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES. CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1234

Suitable for Light Railway, Tramway and General Power Transmission. A complete GENERATING PLANT of 1000 Kw. capacity is available for immediate delivery, comprising two 500 Kw. high-speed, enclosed, Compound Engines and Dick-Kerr Dynamos, 500 550 Volts D.C., Allen's Surface Condensing Plant, Edwards' and other Pumps, Baker Separator, piping, valves, &c., complete. Very low price—excellent condition. Also DIESEL ENGINES, 350/1200 HP. JENNINGS, West Walls, Newcastle-on-Tyne. 978

P. & W. MacLellan, Ltd., CLUTHA WORKS, GLASGOW. MANUFACTURERS OF RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION. RAILWAY IRONWORK, BRIDGES, ROOFING, &c. Chief Offices: 129, Trongate, Glasgow. Od 3547 Registered Offices: Clutha House, 10, Princes St., Westminster, S.W. 1.

Patent See's Hydro-Pneumatic Ash Ejector. Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4835

Iron and Steel Tubes and Fittings. Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817 The Scottish Tube Co., Ltd., HEAD OFFICE: 34, Robertson Street, Glasgow. See Advertisement page 99.

Royles Limited, ENGINEERS, IRLAM, MANCHESTER. FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM and GAS KETTLES, } ROW'S PATENTS. Merrill's Patent TWIN STRAINERS for Pump Suctions. SYPHONIA STEAM TRAPS, REDUCING VALVES High-class GUNMETAL STEAM FITTINGS. WATER SOFTENING and FILTERING. 5723

IRON & STEEL Tubes AND Fittings AND Steel Plates. STEWARTS AND LLOYDS, Ltd. GLASGOW - BIRMINGHAM - LONDON. See Advertisement Page 102. 1111

Drag Line Excavator. Has moved 2,000 cube yards in one day. May be seen at Frodsham, near Chester. Reach 77 ft.; lift four to five tons; speed of working, one to three cuts a minute. HARRY FAIRCLOUGH, Contractor, WARRINGTON. 1107

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Three sets of THREE THROW HYDRAULIC PUMPS, rams 3 in. diam., 12 in. stroke, 2 tons pressure per square inch.

Set of Nearly New THREE THROW HYDRAULIC PUMPS, 4 in. rams, 12 in. stroke, driven by 130 HP. D.C. MOTOR, 500 volts, 213 amps, 485 revs.

NEARLY NEW HYDRAULIC ACCUMULATOR, ram 18 in. diam., 20 ft. stroke, 220 gallons capacity.

NEARLY NEW HYDRAULIC INTENSIFIER, rams 17 in by 9½ in., 5ft. stroke, capacity 145 gallons, hyd. pressure 1500 lbs., intensified pressure 3 tons.

FIVE 150 ton HYDRAULIC FORGING and PIERCING PRESSES, ram 19 in. diam., stroke, 2 ft. 9 in., working pressure 1500 lbs.

No 9. PULSOMETER PUMP, 7 in. suction, with foot valve and strainer.

WORTHINGTON HORIZONTAL DUPLEX PUMP, 14 in. by 12 in. by 10 in., 10 in. suction, 8 in. delivery.

250 Kw. GENERATING SET, Triple Expansion Engine by Bellis & Morcom, direct coupled to Generator, 460/550 volts, 380 revs.

160 Kw. 3 Phase GENERATING SET, Compound Engine direct coupled to 3 Phase Alternator, 550 volts per phase, 40 cycles, 174 amps, 300 revs.

Three 75 B.HP. SHUNT WOUND MOTORS, by Vickers, continuous rating, 440 volts, 600 revs, with pulley.

One 150 B.HP. VERTICAL FOUR CYLINDER DIESEL ENGINE, by Mirrlees Watson and Co., Ltd., number 138805 B., cyls. 11½ in.; stroke 12 in. Special adjustment gear to run in parallel four stroke cycle type, solid flywheel, 4 ft. diam. by 1 ft. face, with two stage Air Compressors; direct coupled to multipole D.C. Generator, by Siemens Bros. Ltd., 105 volts, 1000 amps, 400-420 revs. Spare Armature and large complement of Spares. Rails Inverkeithing. CATALOGUE of Stock MACHINERY, 6000 Lots, Free on Application. Inspection Invited. Thos. W. Ward, Ltd., ALBION WORKS, SHEFFIELD. 1006

Carels Diesel & Steam Engines. CARELS DIESEL & STEAM ENGINES (LONDON), LTD. Carlton House, Regent Street, London, S.W. 1. Telephone: Regent 3434. 1120

YARROW & CO. (1922), LTD., GLASGOW. LAND AND MARINE YARROW BOILERS. 819

John Bellamy Limited, MILLWALL, LONDON, E. GENERAL CONSTRUCTIONAL ENGINEERS. 1216 Boilers, Tanks & Mooring Buoys STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

RAILWAY AND TRAMWAY ROLLING STOCK. Hurst, Nelson & Co., Ltd., THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3383

Head, Wrightson & Co., LIMITED. See Advertisement page 62, March 9. 2402

Matthew Paul & Co., Ltd. LEVENFORD WORKS, Dumbarton. 763 See Full Page Advt., page 56, March 2.

Taylor & Challen Presses For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER. Foundry, Works, and Showrooms: BIRMINGHAM. See half page advert., page 59, March 2. 8198

Railway Switches and Crossings. T. SUMMERSON & SONS, LIMITED, DARLINGTON. 1313

GOLD MEDAL-INVENTIONS EXHIBITION-AWARDED Duckham's Patent Suspended WEIGHING MACHINES.—MAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD. LONDON, E.—Hydraulic Cranes, Grain Elevators, &c. See illus. Advt. last week, page 15. 991

WAYGOOD-OTIS LIFTS 710 54 & 55, PETTER LANE, LONDON, E.C. 4. 62 & 63, LIONEL STREET, BIRMINGHAM, and Principal Provincial Cities.

For Your Repairs or any SPECIAL MACHINERY, try— THOMAS HUNT & SONS, Albion Ironworks, Bridge Road West, Battersea, S.W. 11. Est. 1854. 1313

Aluminium in Rolling-stock Reduces Weight Power and Maintenance Costs. *British Aluminium Co., Ltd.,* 109, Queen Victoria St., London. 1309

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For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

Founded 1854 by Sir WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 1311

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A Brochure describing our Special Course of training in the lucrative field of "ENGINEERING SALESMANSHIP and SALES MANAGEMENT" will be sent on application to DIRECTOR, THE INSTITUTE OF ENGINEERING SALESMANSHIP, 233, Oxford Rd., Manchester. 1119

Powering of Vessels.—A Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 1049, Offices of ENGINEERING.

TENDERS.

CORPORATION OF CALCUTTA.

NOTICE TO CONTRACTORS.

The Time for the Submission of Tenders for the Supply, Erection and Installation of an Aerial Ropeway for the Removal of the City Refuse has been EXTENDED from 30th April, 1923, to 1st June, 1923. Tenders must reach the Deputy Chairman, Corporation of Calcutta, 5, Corporation Street, on or before Two p.m. on Friday, the 1st June, 1923, instead of Monday, the 30th April, 1923, as previously advertised.

JAMES R. COATS, B.Sc., M.I.C.E., Chief Engineer.

Central Municipal Office.
20th February, 1923. X 869

BELFAST HARBOUR.

The Belfast Harbour Commissioners are prepared to receive

Tenders from Competent Dredging Contractors for the work of DREDGING, CONVEYING and DEPOSITING certain MATERIALS within, and in the neighbourhood of, the Port and Harbour of Belfast.

Specification, Form of Tender, and any further information may be obtained from the Harbour Engineer, Mr. T. S. GILBERT, M.Inst.C.E.

Sealed Tenders, on the special form provided for the purpose, should be addressed to the undersigned, endorsed "Tender for Dredging, Conveying and Depositing Dredged Material," and delivered not later than Wednesday, the 28th March, 1923.

The Commissioners do not bind themselves to accept the lowest or any Tender.

M. J. WATKINS, General Manager and Secretary.

Harbour Office, Belfast.
7th March, 1923. X 861

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form, Specification, Contract Conditions and Drawings may be obtained or inspected at the office of

THE AGENT-GENERAL FOR VICTORIA, Melbourne Place, Strand, London, W.C. 2.

SPECIFICATION No. 23/26.

WATER SCREENING PLANT.

Prospective tenderers without Australian Representation should note that time does not permit of their detailed Tender being received at this Office by date of closing of Tenders, and should therefore cable direct, the following particulars:—

1. Price.
2. Delivery.
3. Particulars marked with an asterisk in the Schedule of Plant details.
4. Whether or not one set may be delivered before the complete plant, and if so at what date.

Detailed Tender on prescribed form should be posted by earliest possible mail.

The Commission does not bind itself to accept the lowest or any Tender.

R. LIDDELOW, Secretary,

State Electricity Commission of Victoria, Melbourne, Australia. X 726

THE DUBLIN PORT AND DOCKS BOARD are prepared to receive

Proposals to Supply the undermentioned ARTICLES for the term of Nine Months, ending on 31st day of December, 1923:—

CHAINS.
CORDAGE.

Securities will be required. The lowest Tender, or any, will not necessarily be accepted.

Preference will be given, after due regard to price and quality, to articles manufactured in Ireland.

Sealed Tenders, addressed to the undersigned, and endorsed on the outside "Tender for....." (naming the articles), will be received at this Office up to Tuesday morning, the 27th March, 1923.

Forms of Proposal may be had at this Office between the hours of Ten and Four o'clock.

(By Order),
R. H. BAILEY, Secretary.

Port and Docks Office,
Westmoreland Street,
Dublin, 10th March, 1923. X 893

BARODA STATE RAILWAYS.

Tenders are Invited for the SUPPLY of 27,500 DOGSPIKES. Copies of the Specification can be obtained at the offices of Messrs. RENDEL, PALMER & TRITTON, 12/14, Dartmouth Street, Westminster, S.W. 1, on payment of 3s. 6d. each. This fee will not be returned. Tenders must be delivered to the above address not later than Noon on 27th March. X 871

THE HIGH COMMISSIONER FOR INDIA is prepared to receive

Tenders for the Supply of:—

1. STEEL TYRES for Engines and Tenders.
2. STEEL CRANK and STRAIGHT AXLES for Locomotives.

Forms of Tender may be obtained from the Director-General, India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, and Tenders are to be delivered at that Office not later than Two o'clock p.m. on Tuesday, the 10th April, 1923.

T. RYAN, Director-General. X 872

THE DUBLIN PORT AND DOCKS BOARD is prepared to receive

Tenders for 24 Tipping BUCKETS suitable for discharging coal, ore, and phosphates out of vessels.

Particulars can be obtained on application at the Engineer's Office, East Wall. Tenders to be delivered to the SECRETARY, Dublin Port and Docks Board, Westmoreland Street, Dublin, on or before Tuesday, 3rd April, 1923, and to be endorsed on the outside "Tenders for Tipping Buckets."

The Board does not bind itself to accept the lowest or any Tender.

Dublin Port and Docks Office.
10th March, 1923. X 892

DUBLIN PORT AND DOCKS BOARD.

The Dublin Port and Docks Board is prepared to receive

Tenders for One Concrete MIXER with Steam-driven Engine.

The Mixer shall have an output of 30 cubic yards per hour.

Particulars can be obtained on application at the Engineer's Office, East Wall, Dublin.

Tenders to be delivered to the SECRETARY, Port and Docks Board, Westmoreland Street, Dublin, on or before Tuesday, 27th March, 1923, and endorsed "Tender for Mixer."

The Board does not bind itself to accept the lowest or any Tender.

Dublin Port and Docks Office.
6th March, 1923. X 891

AKTIEBOLAGET KVAERINDUSTRI

Offers For Sale its Factory BUILDINGS and its PATENTS for the MANUFACTURE OF NITROGEN PRODUCTS.

I. Factories for the Manufacturing of Sulphate of Ammodium and Sulphuric Acid, with site of about 70,000 square meters, about 20 kilometres from Gothenburg.

II. Methods of Producing Combinations of Nitrogen, viz.: the production of nitrogen, the purifying of the reaction mixture, catalyzing by means of iron, agglomeration of the reaction mixture, plant for electrical furnace for azotizing, production of oxalic acid and hydrogen.

For the most of these methods have patents been granted or applied for in Sweden, United Kingdom, France, United States, Germany, Italy, Switzerland, Norway and Finland.

The patents include the method known as "the Thorssell method for the chemical production of nitrogen products" (*vide* Tekniska Samfundets i Goteborg handlingar, lecture, Nr. 1, 1920 and "Zeitschrift fur angewandte Chemie," Jahrgang 33, No. 80, 83 u, 84 vom 5, 12 u, 19 Oktober, 1920).

Offers for the real estate, the method or part thereof or the right to exploit it in any particular country are received until the 15th of April, 1923, of the undersigned who also answers all enquiries.

Gothenburg,
the 19th February, 1923.

TORSTEN SMITTHERBERG, Solicitor.

V. Hamngatan 10,
Gothenburg,
Sweden. X 896

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

Tenders for the Supply of:—

Two "S.P." Class LOCOMOTIVE ENGINES and TENDERS (Broad Gauge).
Five "K" Class LOCOMOTIVE ENGINES and TENDERS (Broad Gauge).

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tenders for Locomotives," must be left with the undersigned not later than Twelve Noon on Friday, the 13th April, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of £2 for each copy of the Specification.

Copies of the Drawings may be obtained at the Offices of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD, Managing Director.

91, Petty France, S.W.1.
13th March, 1923. X 884

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the following STORES, namely:—

	Fee for Specification.
No. 1.—Copper Plates and Phosphor Copper	10s.
No. 2.—Spare Parts of Locomotive Engines	10s.
No. 3.—Ferro Prussiate Paper, &c.	2s. 6d.
No. 4.—Firebricks	2s. 6d.

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Copper Plates, &c.," or, as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 27th March, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE, Secretary.

Company's Offices,
48, Copthall Avenue, E.C. 2.
London.
14th March, 1923. X 913

COUNTY OF LONDON.

The London County Council invites

Tenders for the Road-work and PLATE-LAYING required for the Construction for the Overhead System of Traction of the authorised Tramway in Ambarst Park, from Seven Sisters Road to Stamford Hill, and for the RECONSTRUCTION and WIDENING of the BRIDGE carrying Seven Sisters Road over the New River. The paving of the breasts of the carriageway along the route length will also be included in the contract.

The Contractor will be required to use the rails with their fastenings, and the special work for the various crossovers, etc., which will be provided by the Council under other contracts, but all the remaining metal work and other materials will be included in the contract.

Persons desiring to Tender may obtain the Specifications, Bills of Quantities, Forms of Tender, Drawings, etc., on application to the Chief Engineer of the Council, at the Old County Hall, Spring Gardens, S.W.1, upon payment of the sum of £5. This amount will be returnable only if a *bona fide* Tender is submitted, and not withdrawn. Full particulars of the work and conditions of contract may be obtained at the Old County Hall before payment of this fee.

No tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after Four p.m. on Monday, 9th April, 1923, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD, Clerk of the London County Council. X 908

APPOINTMENTS OPEN.

THE ROYAL TECHNICAL COLLEGE, GLASGOW.

The Governors invite

Applications for the Chair of ELECTRICAL ENGINEERING, from which Professor Magnus Maclean, M.A., D.Sc., LL.D., is about to retire. Salary £1000.

Applications and testimonials should be sent, not later than 22nd March, to the DIRECTOR of the COLLEGE, from whom further particulars may be obtained. X 847

CAPE TECHNICAL COLLEGE, CAPE TOWN.

Applications are Invited for the following POST.

LECTURER IN MECHANICAL ENGINEERING, Salary £400—25—600.

Applications, which will be received up to the 31st March, 1923, must be accompanied by certified copies of testimonials of training and teaching experience and should state age of applicant. Holders of such posts may be required to join the Government Provident Scheme. Two year's probation, subject to six month's notice on either side, afterwards, three month's notice. £50 allowed for travelling expenses but a proportionate amount of this to be repaid if the contract is terminated in less than two years. Long leave after six years, three months on full, three months on half salary. Applications to be sent to Messrs. CHALMERS, GUTHRIE & CO., LTD., 9, Idol Lane, London, E.C. 3. X 895

H.M. SIGNAL SCHOOL, R.N. BARRACKS, PORTSMOUTH.

Applications are Invited for TWO VACANCIES for ENGINEERS, Grade II., in the Laboratory Section of the above School. The duties concern the development of Wireless Telegraphy, etc., for Naval purposes. Preference given to candidates possessing an Honours Degree in Physics or Electrical Engineering.

The salary scale is £150, rising by annual increments of £10 to £300 per annum, plus bonus based on the average cost of living figure. The minimum pay plus bonus at present is £344 per annum.

The appointments are not established and the Federated Universities Superannuation Scheme is applicable.

Applications, giving full particulars of the candidate's experience, War Service, etc., should be addressed to "THE SECRETARY OF THE ADMIRALTY (C.E.), Admiralty, S.W.1," from whom further particulars of the duties, etc., can be obtained. X 902

Applications are Wanted for the POSITION of GENERAL MANAGER of Associated British Machine Tool Makers Ltd.—Apply, by letter, giving full particulars of qualifications, salary required, etc., to THE CHAIRMAN, 17, Grosvenor Gardens, London, S.W.1. X 909

RESEARCH APPOINTMENT UNDER THE MINES DEPARTMENT.

THE SECRETARY FOR MINES invites

Applications for a Post under the Safety in Mines Research Board. The appointment is a whole-time one and the provisions of the Federated Universities Superannuation Scheme apply. The salary, including superannuation contributions and all other emoluments, will depend upon the qualifications of the candidate selected, and will not exceed £2000 per annum.

Candidates must possess high general scientific qualifications and experience in engineering, and a knowledge of coal mining will be a recommendation. The holder of the appointment will be required to advise the Board on questions of research in regard to the safety problems of coal mining, to prepare programmes of research, to organise and supervise research work, and generally to co-ordinate the scientific work of the Board. It will also be his duty to prepare a scheme for the centralisation of the research work of the Board in a permanent Station.

Applications, which should be addressed to the UNDER SECRETARY FOR MINES, Mines Department, Dean Stanley Street, London, S.W.1, should reach that address not later than 30th April, 1923. X

Wanted, Town Superintendent for Water Works on East Coast. Population about 60,000. Experience in distribution, main-laying, waste detection, keeping of pipe plans and records, plumbing, fittings, meters, stores and Office routine. Good management of all classes of workmen. Salary £300 per annum with house. Age 30 to 45. Application in own handwriting with three recent testimonials.—Address, X 801, Offices of ENGINEERING.

MANCHESTER MUNICIPAL COLLEGE OF TECHNOLOGY.

APPOINTMENT OF INSTRUCTOR IN THE MECHANICAL ENGINEERING WORKSHOPS.

Applications are Invited for the POSITION of INSTRUCTOR in the Mechanical Engineering Workshops of the College at a salary of £235 per annum. The person appointed will be required to give practical instruction in fitting, turning, and such machine work as generally obtains in Engineering Workshop Practice. It is desirable that applicants should hold the 1st class Teacher's Certificate in Manual Training (Metalwork) of the City and Guilds of London Institute.

Applications, giving full particulars of qualifications, with copies of not more than three recent testimonials, should be forwarded to the REGISTRAR of the College on or before 26th March, 1923. X

SHANGHAI MUNICIPAL COUNCIL.

PUBLIC WORKS DEPARTMENT.

CLERKS OF WORKS.

Four Fully Qualified Clerks OF WORKS are REQUIRED in the Public Works Department of the Shanghai Municipal Council. Candidates must be about 30 years of age and unmarried. Preference will be given to applicants thoroughly experienced in sewer construction and general engineering work. Salary Taels 285 per mensem, under a three years' agreement, which is renewable at a higher salary in the event of satisfactory services. Second-class passage is granted, with half pay during voyage. Free medical attendance is provided, and the Employee participates in the benefits of a Superannuation Fund. A tael at the present rate of exchange equals 3/1; exchange is, however, subject to fluctuation. Taels 285 per mensem at exchange 3/1 is equivalent to about £537 per annum.

Particulars of the appointments and also full details as to the benefits enjoyed by Municipal Employees under their Terms of Service, may be obtained from the Council's Agents, and applications in candidates' own handwriting, with full information as to experience, etc., accompanied by copies of at least three recent testimonials, and endorsed "Clerk of Works" on the cover, should be forwarded at the earliest possible moment to:—

Messrs. JOHN POOK & CO.,
Agents for the Municipal Council of Shanghai,
68, Fenchurch Street, E.C. 3. X

SHANGHAI MUNICIPAL COUNCIL.

PUBLIC WORKS DEPARTMENT.

ASSISTANT ENGINEER.

A Fully Qualified Assistant ENGINEER is REQUIRED in the Public Works Department of the Shanghai Municipal Council. Candidates must be between 28 and 32 years of age, and unmarried. They should hold the testamur of the Institution of Municipal and County Engineers, or have passed the examination for the Associate Membership of the Institution of Civil Engineers, or hold a degree in Engineering from a University in Great Britain. They should also have had at least two years' experience on constructional works.

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March, 1923. X

REINFORCED CONCRETE PIER AT SHELLHAVEN.

OWING to a large increase in business it became necessary some time ago for Messrs. Shell-Mex, Limited, of London, to consider the question of improving their facilities for accommodating tank steamers in the Thames. It was desired to afford discharging accommodation for large vessels unloading petroleum and other oils, and the decision was come to that this could be best arranged by the enlargement of their pier at Shellhaven, near Thameshaven. The old pier consisted of a jetty carried on timber piling, with a deck width of only 8 ft., with an extension on each side to carry pipe lines. At the end of this jetty was a pier head which was only 40 ft. long by 20 ft. wide. Up and down-stream of the pier head were two independent timber dolphins to assist in keeping in position the vessels making use of the pier.

The new pier was designed as a much more extensive structure, and was placed contiguous to the old so that the old pier head has been virtually built into the new, while the new jetty from the shore runs alongside the old. In Plate XXII, the present page and pages 320 and 334, we give illustrations of the new pier, and several of these incidentally show the old structure. Both old and new structures may be discerned in the general views of the jetty and pier head given in Figs. 1 and 2 above while Fig. 8, Plate XXII, in particular will make the extent of the old structure clear. The old pier was a light iron structure carried on wooden piles. It had been in existence about seven years when the extension was under consideration, and in that time it had suffered such damage from *teredo navalis* that in many cases little was left of the piles. To cope with this destruction the piles of the old pier have been encased in iron jacketing, which is carried down into the mud and up well above low water, and then filled with cement.

In order to avoid similar destruction occurring to the new structure it was decided to build this of reinforced concrete, which offered additional security in the case of fire, a point of considerable moment where so much inflammable material is handled. The survey and preliminary plans were prepared by the Asiatic Petroleum Co. under the supervision of the Company's Engineers. Messrs. Edmond Coignet, Limited, were appointed consulting engineers for the work and the pier was constructed to their designs by Messrs. John Mowlem and Co., Limited, London. The new pier consists of an approach 560 ft. long and a pierhead 370 ft. in length. The length of the head structure was originally intended to be 460 ft., but this was subsequently modified. At the shore end the approach widens out so as to be triangular in plan, as will be shown in Fig. 8. Fig. 4 gives a longitudinal section of the shore jetty, and Fig. 5 an elevation of the pier head. In the latter is shown, in dotted lines, the original pierhead 40 ft. long. The platform width of the new jetty is 18 ft., giving much greater accommodation for pipe lines as well as for tracks of light rails and room for handling barrels, &c.

Dealing first with the shore jetty, a typical portion of which is shown in the view Fig. 35, page 334, this was built on 14-in. octagonal reinforced concrete piles of lengths running up to 50 ft. They are spaced at about 16 ft. centres lengthwise, and 15 ft. across the jetty. The decking is carried by main beams, 2 ft. 1 in. deep, across the jetty (Figs. 12 and 14) and four secondary longitudinal beams, 1 ft. 5 in. deep, between the main beams. The secondary beams are shown in Figs. 13 and 15. Their depth is increased where they run into the main beams. Towards the shore end the height above ground level was not such as to necessitate bracing between the piles (see Fig. 9), but as the shore fell away and the height increased, bracing was introduced. In the centre of the jetty's length this bracing consisted of horizontals between the piles both in the longitudinal and transverse directions, and alternating transverse diagonals. The arrangement will be clear from the view Fig. 10, while details are shown both longitudinally and across the jetty in Figs. 14 and 15. Still further out, as will be seen from Figs. 4 and 11, similar bracing was introduced in two tiers, the diagonals again being alternately arranged in one direction or the other. This will be seen in greater detail in Figs. 12 and 13, which actually give particulars of the reinforcement for the three sets of piles nearest the head end. The piles were reinforced by eight $\frac{5}{8}$-in. rods with $\frac{1}{16}$ in. ties, 6 in. apart. The bracing members were 1 ft. deep by 10 in. wide and were reinforced by means of four longitudinal $\frac{5}{8}$-in. bars and $\frac{3}{16}$ in. spiral ties. The pitch of the latter is 6 in. in the centre and 4 in. at the ends of the braces. Various details of the reinforcement and bracing of the jetty members are given in Figs. 19 to 24, to which we shall revert later on.

The triangular platform at the approach end is composed of decking resting on piles forming for the most part 16 ft. by 16 ft. bays, with similar main and secondary beams. A view taken underneath this part is given in Fig. 36, page 334. A drawing showing a short ramp approach added at the shore end is given in section in Fig. 6. The slab decking is 5 in. thick reinforced with a meshwork of principal and secondary bars tied together with annealed wire. The principal and secondary beams are reinforced with longitudinal bars and tiers, and in the former the longitudinals are bent upwards and hooked so as to resist diagonal tension and shearing stresses. A 30-ft. boatway was left in the jetty at a point indicated in Fig. 4. At this point the longitudinal beams were naturally suitably proportioned.

Since the old structure was left standing in the middle of the new, at the pier head the new work consisted of two distinct sections, one connected with the new jetty, and one independent. Both sections were of 40 ft. width, and they were built with piles set at 15 ft. centres by 10 ft. As will be seen from Figs. 4 and 5, horizontal braces extended throughout the pier head at two levels, between the several rows of piles. At the same time diagonal bracing was introduced at each end of both sections. In some of the illustrations this is rather confused by overlying fendering, to which we shall refer presently, but the diagonals at the outer ends of the pier head are clearly shown at the left-hand end of Fig. 5, and in Fig. 34, page 334. The transverse

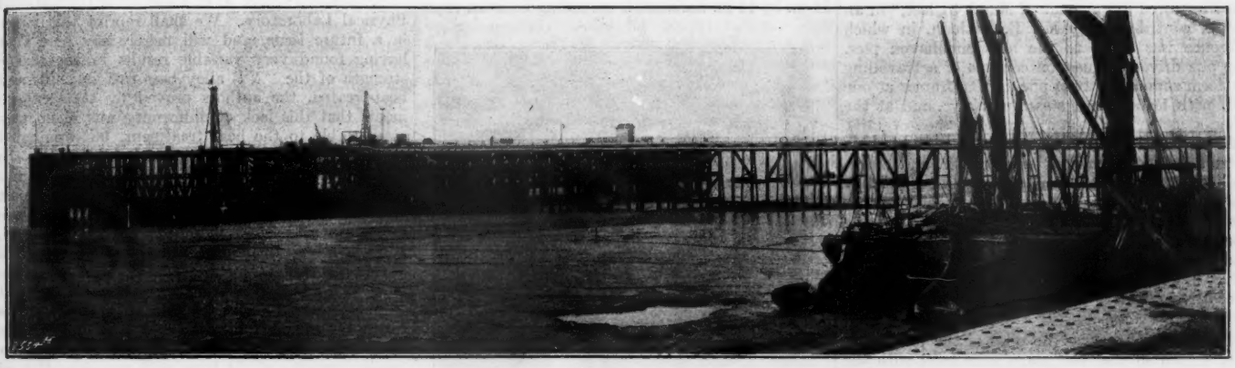


FIG. 1. GENERAL VIEW OF THE OLD AND NEW PIERS.

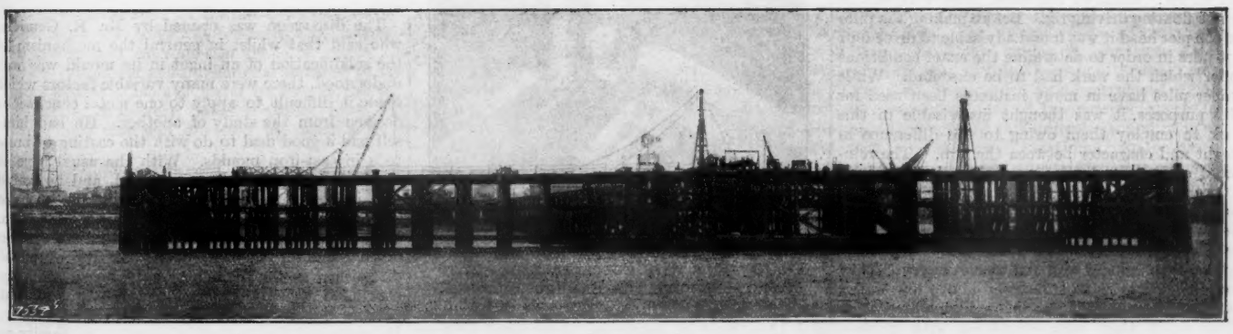


FIG. 2. THE PIERHEAD.

diagonals are shown in Fig. 16, Plate XXII, while the longitudinal diagonals at the inner ends of the two sections of the head, are arranged as shown in Fig. 5 to the left of the old structure. The decking of the pier head is also 5 in. thick. Diagonal bracing is laid under the decking as shown in Fig. 8. This includes ties at the bollards, and, on the longer section, two lines of braces carried over seven bays as shown. The cross-bracing is composed of 15-in. by 16-in. horizontal members and 13-in. by 13-in. diagonals. Details of the reinforcement are given in Figs. 16, 17 and 18. The piles in the pier head were 15 in. octagonal, and the lengths ran to 56 ft.

In the construction of the pier jetty and the head, piles of the former were all driven so that the head was finally level with the deck, while the shoe penetrated well into gravel, to the required set. For most of this work the piles were driven by a special duplex travelling pile driver supplied by the British Steel Piling Company. This pile driver was illustrated in our issue of March 31 last,* in an article, contributed by Mr. E. Latham, in which reference was made to the new Shellhaven pier. The pile driver in question consists of a travelling platform supporting twin pile-driving frames at one end, with leaders and steam monkeys, and at the other a steam boiler and counterbalance of rails. The boiler in this instance was dispensed with as no fires were permitted on the pier, and steam throughout the work was supplied by the company's installation ashore. The pile-driving end of the platform is cantilevered out from the part of the work already completed. Temporary detachable timber beams and braces were used between the driven piles to stiffen them sufficiently to take the pile driver, which, with all gear, weighed about 50 tons.

Beyond the boatway the piles of the jetty were only driven so that the heads were level with the upper tier of bracings, and the same applies to the pier-head sections. The spacing of the piles in the pier head was determined by the width of the twin pile driver. Some of the outer piles were driven from a floating driving rig. Before making the piles for the pier head it was found advisable to drive four test piles in order to determine the exact conditions under which the work had to be executed. While timber piles have in many instances been used for trial purposes, it was thought inadvisable in this work to employ them owing to the difference in weight and character between the two. The reinforced concrete test piles were all driven carefully in positions in which they could ultimately be embodied in the final structure. As stated above, these piles were not carried up to the deck level, as the length required would then have made them awkward to handle and extremely heavy. They were finished so as to stand well above low water, but about a couple of feet below high water, from which point they were completed with reduced reinforcement, *in situ*.

In order to expedite the work it was decided to use pre-cast members for the bracing where possible. In the jetty all horizontal and diagonal braces were so constructed. After the piles were driven the concrete was stripped off the outer surface at the proper points for some height, as depicted in Fig. 3, in order to secure a good bond for the bracing members. The bars of the reinforcement of the braces were left exposed and were bent round the core of the piles, as shown in the details, Figs. 21 to 26, &c., where the pre-cast and *in situ* work are clearly distinguishable. Special wooden boxes were made to enclose these junction points, and the ends cast in this manner in position. A good deal of trouble having been found in obtaining carpenters for the shuttering work, it was further arranged to pre-cast the secondary beams carrying the decking of the approach.

In the case of the pier head the horizontal and diagonal braces were similarly pre-cast, the ends of the reinforcing bars being left exposed to connect up with the piles. Details of the bonding are shown in Figs. 16, 17 and 18. In order to concrete up the junctions of the piles and bracing, steel boxes were adopted in this case as they were found to be more suitable than timbering. The principal and secondary beams and the decking were constructed in the ordinary way in position with wooden forms, &c.

Figs. 19 and 27 to 32 show details of the timber fendering which is of a very elaborate character. The main members of the fendering are 12 in. by 12 in. and 12 in. by 6 in. The details show clearly how this timbering has been fitted to the concrete work and clipped to the piling, &c. The whole of the fendering can be replaced, if necessary, without interfering with the main structure, as in no case do the fastenings enter the concrete. In addition to the main fendering, which extends all round the pier head and is continued down the jetty for some distance to provide berthage for barges, lengths of spring fendering have been arranged at five points on the pier face. This is shown in section in Fig. 20, and can be distinguished in the view given in Fig. 33, page 334. Each section extends over two bays, and consists of a frame of three 14-in. by 14-in. timber piles with 14-in. by 14-in. horizontals extending between them

Fig. 3. Pile with Concrete Removed to Obtain Bonding for Bracing Members.

and 12-in. by 6-in. diagonals. Interposed between these spring frames and the main fendering are coir rope mats, while iron guides and chains are provided to keep the timber framing in position. Mooring buoys are provided both up and down stream to accommodate large vessels, and the bollards on the pierhead are used for spring ropes and for mooring small steamers and barges.

The general idea of the design of the pier head was not so much that of making it a rigid structure, as to provide it with a considerable degree of resilience. Consequently no underwater bracing was introduced. This theory appears to have been amply justified by subsequent events, since the pier has been in use now for over six months and at times tank steamers of as much as 25,000 tons have moored alongside in strong winds without damage to the structure.

The deck of the pier head is laid with block-wood paving. This has been employed to protect the concrete from damage by the rims of the steel barrels handled. The pier head was designed to carry barrels and support the weight of several 7-ton travelling cranes. The approach jetty can accommodate two barrel runs, and pockets are cast below the deck on the side adjoining the old jetty so that joists can be extended to the latter and the intervening space utilised for all the pipe lines running to the pierhead. The pockets are well shown in Fig. 36, on page 334.

Owing to the amount of pre-cast work employed a good deal of organisation was necessary on the part of the contractors, Messrs. John Mowlem and Co., to ensure the parts being brought forward regularly. Mechanical mixers were used in the moulding yard, and for the pier head distribution was by gravity chute. For the piles the mixture employed was 1 : 1½ : 3. Other pre-cast members, however, were made with a 1 : 2 : 4 mixture. The latter was also adopted for the work done *in situ*. Ballast was used for the large aggregate.

* See Engineering, vol. cxiii, page 382.

THE INSTITUTE OF METALS.

(*Continued from page* 310.)

Chill Castings of the "Y" Alloy.

The first paper taken at the afternoon session on the 7th inst., was entitled "The Production and Heat-Treatment of Chill Castings in an Aluminium Alloy," by Dr. Rosenhain, F.R.S., and Messrs. S. L. Archbutt and S. A. E. Wells, all of the National Physical Laboratory. We shall reprint this paper in a future issue, and will merely say here that having found very variable results in the tensile strength of the "Y" alloy bars cast in chills and heat-treated, the authors proved by their experiments that this lack of uniformity was in no way attributable to the heat treatment, but originated in too great a depth of chill. By lightening the cast-iron mould so that its sectional area was not more than three times that of the casting, most uniform results were obtained. The mould was dressed with a paste of plumbago and lubricating oil, and was heated to 150 deg. or 200 deg. C., and tilted during pouring to an angle of 30 deg. with the vertical. The best pouring temperature was found to be 750 deg. C., and the rate of pouring such as to fill the mould 7 in. deep and 1 in. in diameter in not less than 10 seconds. Rods thus cast had a tensile strength of 20 tons with an elongation of 5 per cent. to 6 per cent. on 2 in. In fatigue tests the specimens were able to withstand 12,000,000 reversals of a fibre stress equal to 7 tons per square inch.

The discussion was opened by Mr. R. Genders, who said that whilst in general the mechanism of the solidification of an ingot in its mould was well understood, there were many variable factors which made it difficult to apply to one metal conclusions derived from the study of another. He had himself had a good deal to do with the casting of brass rods in cast-iron moulds. With the usual type of mould solidification was very rapid, and he feared that it would in his case be impracticable to make the moulds thin enough to secure slow solidification. He noted that the authors found that on turning down some of their bars the density of metal diminished as the diameter was reduced, and they concluded accordingly that the centre contained cavities due to the rigidity of the chilled surface. He suggested that instead of securing uniformity as the authors had done by reducing the depth of the chill, a similar end might be attained by chilling the metal throughout. Possibly sounder castings might also be secured by using tapered moulds, in which the solidification proceeded from the bottom upwards. The authors had found the surface of the metal was liable to blister, if the heat treatment was effected by means of a salt bath, whilst when carried out in a muffle no blisters were formed. The speaker suggested that this might be due to the greater rapidity of the heating in the salt bath. Any gas occluded might then burst out the surface and form blisters, whilst with slow heating in a muffle the gases might be given time to diffuse through the metal.

Dr. D. Hanson, who spoke next, said that the authors had successfully applied to non-ferrous metals principles which had been successful in the case of ferrous metals. He could not agree with the previous speaker that it would be difficult to apply the methods described to metals with high melting points. A noteworthy point was the very high tensile strength attained. This in one case reached 23·4 tons per square inch, whilst the tensile strength of the wrought metal was 24 tons to 26 tons per square inch. Hence in castings the authors had obtained practically the same properties as characterised the rolled alloy. The reason was that they had secured really good castings. As a general rule we had to deal with bad castings, but he hoped

that further study of the question would ultimately give us castings comparable to the rolled material. Unsound castings might be due either to shrinkage or to an evolution of gas. In the cases described in the paper the main trouble seemed to arise from shrinkage, and whilst the procedure described might eliminate these a different plan would have to be followed to get rid of unsoundness due to gas.

Professor T. Turner was pleased to note that the authors had found that the density of their castings gave an indication of the tensile strength and of the general character of the metal, although the difference between the density of the good and bad material was comparatively small. As Dr. Hanson said, the cavities in this case did not appear to be due to gas, nor were they, the speaker thought, to be classed as ordinary shrinkage cavities. The bars being cast in chills, the metal at one moment during its solidification consisted of a solidified outer shell filled with molten metal in which there was neither gas holes nor cavities, which were in fact produced by subsequent contractions. In the case of the bars described in the paper these cavities formed at the centre of the bars, the metal being an alloy, its composition altered as it cooled, different constituents separating out as the temperature fell. He would like to know therefore whether comparative analyses had been made of the centre and exterior of the bars. In general, constituents having the highest melting-point solidified first and formed the exterior of the casting. There were, however, cases of abnormal segregation in which the most fusible constituent separated out first and formed the outside of the casting, the interior being constituted by a body having something of the character of a chemical compound. To get uniformity it was necessary to adopt a definite rate of cooling, and in the abnormal cases of inverse segregation to which he had referred it was necessary to give sufficient time for diffusion to occur. In the experiments described in the paper it would seem that the segregation was of the normal type, yet here again it was necessary, by adopting a definite rate of cooling, to allow time for the cavities to fill up.

Mr. H. J. Maybrey, who followed, asked whether the authors had tried another shape of mould. In casting brittle alloys in cylindrical moulds, he had found that if a blob of metal formed at the top, the casting was very liable to suffer from hair cracks, and this was obviated by using a taper mould.

Mr. Clark, who spoke next, said that he had found that porosity might be avoided by casting in vacuum. Aluminium ingots thus cast could be rolled down to plates 2 mils. thick, and he had drawn wires from such ingots less than 1 mil. in diameter. When he had started making such sheets from special alloys, sand castings were in vogue. He had since used cast-iron moulds, and would try the author's plan of reducing the thickness of these. The rods he cast ranged from $\frac{1}{2}$ in. up to 1 in. in diameter, and were thus comparable with the authors' specimens. He had got much better results with graphite moulds than with cast-iron ones, especially with nickel chromium alloys. Clay crucibles, he might observe, were very porous even at low temperatures, and still more so at high. Hence with gas heating the products of combustion were liable to diffuse through the crucible. For deoxidising purposes, he had secured specially satisfactory results with an aluminium titanium alloy, which appeared to be the best deoxidiser for non-ferrous metals. He was anxious to try electric melting, which was now being used for melting type metal with a large saving as compared with gas. The process was more under control, the product better, and there was less dross. In view of the ease with which gas diffused through clay he asked whether it was certain that there was no chemical action when a muffle was used for heating the authors' specimens. He thought airtight muffles and furnaces would give better results.

In the absence of Dr. Rosenhain, Mr. S. L. Archbutt replied to the discussion. He said that the cylindrical mould had been used throughout of set purpose, since they had used a similar mould for many anterior investigations, and wished to maintain comparable conditions. With reference to the suggestion that blisters were due to rapid heating he said that blisters did not make their appearance at once, but required time to develop. He thought that the unsoundness noted was due both to shrinkage and to an evolution of gas, and this matter was being further considered. With perfectly sound castings a coarse grain should be as good as a fine one, but apparently there was a difference, and he believed that gas was liberated at the crystal boundaries. In the main, however, the unsoundness of their specimens was due to shrinkage. Professor Turner had suggested that the inferiority of the central part of their bars might be due to a difference in composition, but the speaker did not think that the explanation lay here. It was true, however, that such differences did occur and with the 12 per cent. copper aluminium alloy used for pistons during the war the centre of a casting was found to contain 1 per cent. less than the exterior. Mr. Clark had suggested casting the metal *in vacuo*, and they hoped before long to try this plan at the National Physical Laboratory. He agreed that graphite moulds were very satisfactory, being especially useful for copper alloys. Their own experiences with electric melting had not been favourable, the metal produced being full of holes which rather surprised them. The salt bath used was a 50 : 50 mixture of sodium and potassium nitrates. Their muffle, he might add, was gastight.

The Effects of Annealing on Young's Modulus.

The next paper taken was by Professor F. C. Lea, Dr. V. A. Collins and Dr. E. A. F. Reeve, on "The Modulus of Elasticity of Cold-drawn Metals as a Function of Annealing Temperature." It was read by Dr. Reeve and described experiments in which specimens cut from drawn brass tubing were annealed at different temperatures, and their elastic constants determined. The tubes were respectively of hard material drawn dead hard, and "half hard" material. The experiments indicated that in the unannealed state the hard drawn tubes had an elastic modulus of over 6,700 tons per square inch, whilst the "half hard" material similarly tested had a modulus of 7,535 tons per square inch. Young's modulus for the hard drawn material increased to a maximum of about 8,300 tons per square inch after annealing at 400 deg. C. It then fell with higher annealing temperatures until one of 700 deg. C. was reached. At this temperature a rapid increase occurred, the figure of 14,000 tons per square inch being reached after annealing at 800 deg. C. The "half hard" material was much less erratic so far as the tension modulus was concerned, but on compression the modulus fell rapidly after annealing at 400 deg. C. and then increased again with higher annealing temperatures.

The discussion was opened by Mr. R. N. Greaves, who asked for further particulars of the experiments. The authors stated that great care had been taken to avoid stresses above the elastic limit but some of the loads tabulated, if he understood the figures correctly, seemed inconsistent with this statement. The ultimate strengths tabulated by the authors seemed to the speaker very high for such material. The authors nowhere defined what they understood by the range of perfect elasticity. A common definition was that it was the range of stress within which there was no permanent set. This definition was inadequate as there were many materials which in this sense were perfectly elastic, but which nevertheless failed to obey Hooke's law. Unless this law were obeyed the elastic modulus was not a constant. The authors stated that the elastic modulus in compression was less than that in tension, and he would like to know whether they really meant that there was a discontinuity in the modulus in passing from a small tension through zero to a small compression. Unless there was such a discontinuity the elastic moduli found would depend on the range of stress over which they were measured.

Dr. Johnson, who spoke next, asked how the Brinell tests mentioned in the paper had been made.

Dr. Hanson said that he wished to emphasise what Mr. Greaves had said as to the necessity of defining the elastic range. Without this the results recorded were meaningless. With pure copper it was impossible to define an elastic modulus as the stress was never proportional to strain and a permanent set occurred under stresses as low as $\frac{1}{10}$ ton per square inch. He thought similar results might be expected with brasses annealed at high temperatures. The authors had made no mention of hysteresis which was often met with even under the elastic limit.

In reply Dr. Reeve said that in no case had the loads imposed exceeded the elastic limit, though in the case of one specimen annealed at 800 deg. C. it had been necessary to keep the stress below half a ton. They had been surprised at the compressive strength shown by cylinders in their compression tests, particularly those in which the length was 1 in. The extensometers used were not well suited to showing the hysteresis loop for brass, but if such a loop were formed they would take the average value over the whole range or else define it for each particular stress. Their results showed that the compression modulus did differ from the tension modulus. In their Brinell tests they used the smaller of the standard loads. The impressions were oval and they measured both the minor and major axes. The results thus obtained were of course merely comparative and not absolute. The elastic range was difficult to define. They had taken it as fixed by the limits of proportionality. This they admitted was not wholly satisfactory. They had also measured, he might add, the bulk modulus of their material and in that case they did find a small hysteresis loop.

Eutectics.

The next paper, by M. Albert M. Portevin, of Paris, on "The Structure of Eutectics," was not read owing to the absence of the author, but the discussion on it was taken forthwith. M. Portevin divides eutectics into four classes, viz.: Type 1, in which regular crystals of one of the constituents are disseminated in the other constituent forming the ground mass of the alloy. In type 2 the regular compact crystals met with in type 1 are replaced by more or less regularly developed dendrites or skeleton crystals, whilst in Type 3 "eutectic" colonies are formed as complex grains more or less spherulitic. The fourth class, Type 4, is the "granular" type, which M. Portevin states has not been met with in the case of metallic eutectics. This may be regarded as an aggregate of particles of each constituent of the eutectic approximately equally developed in all directions and in juxtaposition as in minerals containing two or three constituents. It is the eutectic structure characteristic of eruptic rocks. In the concluding portion of his paper M. Portevin referred to a paper on the same subject read before the Institute of Metals by Mr. F. L. Brady in 1922. In this paper Mr. Brady called attention to the part played by surface tension on eutectic structure, and whilst recognising this M. Portevin said that it was not the sole factor involved, but that other influences such as rate of crystallisation, cohesion and viscosity also had an effect. The discussion was opened by Colonel N. T. Belaiew, who expressed his high appreciation of the splendid micrographs shown by the author. It was interesting to learn that M. Portevin was unacquainted with Mr. Brady's paper until his own was written, and we had thus two independent papers on the same subject. It was also of interest to compare the classifications adopted by the two authors. Mr. Brady had divided eutectics into (1) globular; (2) lamellar; (3) angular; and (4) crystalline, and had tried to bring them together on the hypothesis that surface tension played an important part in the shaping of eutectics. With the globular form he held that both compounds had a high surface tension, whilst the lamellar form was produced when the surface tensions of the two constituents were equal. In the angular form at least one constituent had a low surface tension, whilst in crystalline eutectics the surface tension of both constituents was low. M. Portevin, on the other hand, classified eutectics as (1) regular crystals; (2) dendritic; and (3) as "eutectic colonies." The first of these types corresponded to Mr. Brady's crystalline class, but M. Portevin had nothing directly corresponding to Mr. Brady's class 2. It seemed to the speaker that the angular type in Mr. Brady's scheme might correspond to M. Portevin's second type. This dendritic type implied a high velocity of crystallisation

and hence according to Mr. Brady a low surface tension. The last type of M. Portevin was constituted by Benedick's "eutectic colonies," and here again it was possible to find in this class substances which would give the lamellar structure of Mr. Brady, and indeed this seemed to be shown in some of M. Portevin's micrographs, particularly if it were borne in mind that the lamellæ might be cut at different angles by the cross section. The term lamellar must not, however, be taken too literally in speaking of eutectics and eutectoids. With the latter as was shown by pearlite, the crystals formed from the solid state and the plane of crystallisation was fixed. Eutectics crystallised from the liquid and then there was no governing plane of crystallisation.

Professor Turner said that he thought Mr. Brady was fortunate in that, being a young man, his paper had been published before that of M. Portevin, who had a world-wide reputation.

Dr. Hanson, who spoke next, said that M. Portevin's paper was the most complete discussion of the subject he had yet seen. The author had proved that these eutectics were not as simple as had at one time been thought. The speaker agreed with the author that the lamellar type of eutectic was very rare, though the structure was common with eutectoids, that of aluminium zinc being very similar to pearlite and truly lamellar. Eutectics, on the other hand, were more rod-like. One point that had struck the speaker was that one constituent always formed a continuous phase round the other and might be called the enveloping constituent. This, he thought, was an important point. He would also point out that eutectics were not necessarily duplex substances. The relative proportion of the constituents might vary to any extent and a eutectic might contain, say, 99½ per cent. of one constituent and but ½ per cent. of the other. Indeed, it was theoretically possible to have a eutectic consisting of one constituent only.

Defects in Extruded Brass.

Mr. R. Genders then read a short note on "The Extrusion Defects of Brass Rods Extruded from a Multiple Die." This described defects found in 60–40 brass rods extruded from a die having three holes in parallel, set at about 2-in. centres. The author concluded that as in the case of rods extruded from a single hole defects are confined to a portion of the extruded rod and could be avoided by sufficient discard. There was no discussion on this note.

Season Cracking of Brass.

The last paper taken was contributed by Mr. S. Beckinsale, and described "Further Studies in Season Cracking and its Prevention: the Removal of Internal Stress in 60–40 Brass." The paper described various methods of removing internal stresses in 60–40 brass, the efficiency of these being tested by measuring the reduction of the internal stress and also by observing the behaviour of treated articles in mercurous nitrate solution. Certain mechanical processes such as "reeling" were found effective, but there was a danger of over "reeling" the material. Hammering and malleting were unsatisfactory, and by far the best results were obtained by low temperature annealing, the amount of internal stress being appreciably reduced even by one hour's annealing at 100 deg. C. The temperature recommended is, however, between 175 deg. C. and 200 deg. C., the period allowed being 20 to 30 minutes. Such treatment will, the author states, reduce internal stresses to a safe amount with but slight effect on the mechanical properties of any but the most severely worked specimens of the alloy.

There was no discussion.

The members reassembled on the morning of Thursday, the 8th inst.

Aluminium-Copper Alloys.

The first paper taken was on the subject of "Some Properties of the Copper-Rich Aluminium-Copper Alloys," by Mr. R. C. Reader, who read it in abstract. It gave the results of experimental work as to density, volume changes during and after solidification, self-annealing properties and the effect of heat-treatment on the 10 per cent. alloy. Both sand and chill-cast specimens were examined. The author pointed out that the time of the anneal was of great importance; in the experiments it was 20 minutes. If the period were unduly long, sufficient time was allowed for the alpha grains to increase in size and the beta grains to decompose, thus ruining the excellent mechanical properties which may be imparted to aluminium copper by heat-treatment. We reproduce this paper in abstract on page 344.

The discussion was opened by Mr. D. Stockdale, who said, with reference to the author's diagram (Fig. 6) taken from the paper by J. H. Andrew, of 1915, that Andrew was only interested in the changes in the solid state. Andrew had copied it from Curry, and the latter had stated that additions of aluminium to copper raised the melting-point of copper, whilst other researchers said that such was not the case. Curry's copper contained copper oxide. The eutectic composition had not 10 per cent. of aluminium, but 8·5 per cent. He (the speaker) found about 10 deg. difference between the liquidus and solidus. The author's maximum (Fig. 6) at just above 4 per cent. of aluminium occurred at about the curious break which he (the speaker) found in the liquidus, at about 3·5 per cent. of aluminium. With reference to the author's quenching diagram (Fig. 9) he (the speaker) thought that the nearer the eutectoid point at which quenching took place, the greater was the ductility. His (the speaker's) annealing time was about 30 minutes for every 10 deg. C. The paper was of value in that it called attention to the time factor, and this was a most important factor. The properties of the alloys varied according to the rate of cooling even more than according to the point from which they were quenched. The beta constituent broke down more easily than one thought it did.

Professor Carpenter welcomed this first contribution by the author. The author had given density curves of the series plotted together with those showing the results given in Carpenter and Edwards' eighth report to the Alloys Research Committee, these latter curves being above the author's; in this connection, the author had said that the alloys, both sand and chill cast, were more dense than would be expected from the calculated theoretical curve, and Professor Carpenter asked how he had deduced his curve. In the report in question it was stated that a density determination of the delta constituent was very difficult to arrive at, and in this light the difference occurring in the curves could be explained. The author had used in his paper the term "self-annealing," a term which he (the speaker) did not think was the correct one to apply. It was a special reference to self-annealing which did not meet the case. The author had also said that a casting of 10 per cent. aluminium-copper alloy, normally cooled, will be in a metastable state, the beta inversion having been prevented. He (the speaker) was afraid he would have to contradict that statement absolutely, so far, at all events, as regarded the reference to the "beta inversion." The value of the paper resided in the emphasis which it laid on the time factor, and from that point of view it was a helpful one.

Professor Edwards called attention to the difference in hardness which occurred when quenching from 800 deg. and from 900 deg., also to the part played by the rate of cooling and to the velocity of cooling as combined with the quenching temperature. He thought the author's curve for changes of volume (Fig. 6) was interesting, since it cast a reflection on the Carpenter and Edwards' results obtained in a quite different connection; the latter did find a peculiar break in the alloys of the alpha series, particularly in ductility. These alloys showed an increase in ductility as the aluminium increased, then a decrease and then another sudden increase; the changes were no doubt connected with the volume changes the author obtained. In regard to density, the phases had to be considered, and if one had a compound next to the delta or the beta constituent, then the delta or beta must find itself in the solid solution. He suggested that the author should extend his work and obtain useful information on the effect of the rate of cooling on the properties of the alloys in another way. If these alloys all have the beta constituent, in order to facilitate their use in the foundry, one must ascertain how the beta inversion can be retarded by other constituents. One would then obtain an extremely useful alloy for commercial purposes.

Professor Turner stated that the author's 10 per cent. aluminium alloy was an extremely beautiful one, having attractive properties from the mechanical and corrosion resisting points of view. The fact that it behaved in an irregular manner in ordinary foundry practice and occasionally gave unsound castings had not yet been determined. "Self-annealing" was a term which referred to the harmful results due to slow cooling. It was perhaps not a good term in this particular case. It was one used by our American friends. In the author's diagram (Fig. 1) giving the density of the series, he (Professor Turner) was responsible for the "theoretical curve"; this was a short appellation for a curve indicating where no change of volume took place, to replace a term such as "no change of volume curve." Too much attention should not be given to the exact value of the curves of rate of cooling, since the size of a casting, that of the mould, and other factors came in. The author's volume change curve should be taken as depicting the general change taking place. The main object of the paper was to give the manufacturer facts and deductions enabling him to obtain regular, uniform and satisfactory material; it formed, as it were, a connecting link between the report by Professors Carpenter and Edwards, and the manufacturer.

Mr. A. L. Norbury found that the author's curves were practically similar to his own, and Dr. H. W. Brownsdon stated that the author's work would be helpful to the practical man, adding that these aluminium bronzes were not generally used in the shape of castings, but were amenable to hot work, by pressing, rolling into strip, and so forth. Such an alloy was used for the present French coinage. There might be some difficulty in transferring the author's small laboratory experiments in cast bars to actual foundry work. These alloys were affected by impurities and the author gave no analyses. Iron and manganese came in as impurities, and from the paper no deductions could be made as to their effect. The paper read on the preceding day on the "Y" alloy contained a large number of data which would be useful in actual manufacture. The question of mass played an important part, for which evidence obtained on small bars would hardly be serviceable. The rate of cooling in large masses, to take only one instance, was different from that in small bars. The ingot thickness relatively to the mould thickness also came in.

Mr. Reader, in complementing the facts given by Professor Turner, said that he was carrying out his work at the same time as Andrew was carrying out his own. The latter's diagram was therefore not then available. He (the speaker) had quenched in steps of 100 deg. down and perhaps even in longer steps. In regard to the beta inversion, if the magnification were large enough, the beta could be seen duplex, but at a 100-diameter magnification, as reproduced in the micro-sections in the paper, it was seen uniform. He was glad Mr. Norbury's figures confirmed his own. In reply to Dr. Brownsdon, in laboratory work, one was always limited to small-size specimens, the question of cost came in largely; several of the bars, however, were of a size which rendered the work on a par with commercial practice.

Copper-Aluminium-Nickel.

The second paper taken on Thursday morning was on "The Ternary System Copper-Aluminium-Nickel," by Mr. C. R. Austin and Mr. A. J. Murphy. It was read in abstract by the former.

It opened with data on the copper-aluminium, nickel-aluminium and copper-nickel binary systems, described the manufacture of the particular ternary system dealt with, and gave the results obtained with a very large number of alloys made of this system.

Dr. Haughton congratulated the authors on the courage they had displayed in conducting such a very large research; the quantity of alloys they had dealt with was really enormous. He would discuss only the aluminium corner of their diagrams, although he had been most interested in the whole of their paper. He was very much surprised that they had made no reference to the difficulty in finding the liquidus, and he concluded thereby that

they had not found it. He then drew a curve on the blackboard showing what part of the authors' results agreed with his. He asked whether they had taken heating curves, since he thought theirs were only cooling curves. The authors had said that nowhere on the liquidus surface had there been observed an invariant point, in other words, they added, the system did not contain a ternary eutectic, nor was there evidence for the existence of a ternary compound at temperatures of fusion. He agreed with the second part of this statement, but not with their references to the ternary eutectic. He considered there was a ternary eutectic.

Mr. T. E. Rooney referred to the large amount of work involved in the chemical analysis of such a large number of samples; segregation was liable to occur and it would have been preferable in some cases to determine the aluminium directly. He asked whether the copper was separated before estimating for nickel.

Dr. D. Hanson stated that the investigations of the kind carried out by the authors upon alloys having a high melting-point were difficult, and asked whether they kept a careful check on the thermo-couples, whether they deteriorated and how; also what class of protective sheaths they used. Very refined methods were necessary to detect accurately the constitution of the ternary system. He did not think the authors' method of determining the solidus was a sound one, it could not be determined from cooling curves. In the ternary system there were aggregations of solid solutions of varied composition. The last portion to solidify was very different from the first. He showed a curve on the blackboard giving the solidus for the authors' particular cooling and asked what were the authors' time and temperature. A coring effect intervened and its consequences were difficult to remove. The chief value of their work at the present stage was the liquidus determination, and this was the most complete so far made.

Professor Edwards said he had seen the authors at their work, had watched their difficulties, but had also to look at the question of costs during the experiments, and the consumption costs particularly at the thermocouples were high. In regard to Dr. Haughton's remarks concerning the ternary eutectic, he (the speaker) might say careful precautions were taken to avoid supercooling, nevertheless the results perhaps were not perfect. He failed to see how one could get a ternary eutectic in a system each two compounds of which did not give a binary eutectic. He thought a great point in the work was that which concerned the remarkable difficulty in measuring the high temperatures such as the authors had; from that point of view the work was far more important than all previous work. All other three metals dealt with formerly had melting points which were modest in comparison.

Mr. D. Stockdale referred to the authors' diagram of the copper-aluminium binary system, and to his contribution to the Swansea meeting (ENGINEERING, vol. cxiv, page 395), and found, after having completed his experiments, that his arguments were not right. He, however, did not agree with the authors' diagram for the portion between 20 per cent. and 30 per cent. of aluminium. In one of the authors' alloys, the one marked 27, containing 14 per cent. of aluminium, and no nickel, there was shown a difference of 12 deg. between the liquidus and solidus; this was too great; he (the speaker) found a difference of 3 deg. or 4 deg.

In the course of his reply, Mr. Murphy, with reference to Dr. Haughton's remarks, said that they had referred to their difficulty in locating the liquidus when they stated that the upper points of alloys lying in one of the fields of the diagram were liable to undercooling; to surmount the difficulty, alloys in this area were agitated as the expected point of solidification was approached, and if this failed to give an arrest, the method of inoculation with a small amount of the solid metal was employed, when satisfactory and consistent determinations were obtained throughout the series. Dr. Haughton's remarks as to discrepancy with him in a particular area were interesting, and they were prepared to admit that his determinations were more accurate than their own in that area. Heating curves were of no very great value for determining the liquidus. They did not find that an analysis was necessary for most of the alloys, but they found that the removal of the copper was advisable before estimating the nickel content. The thermocouples were frequently inspected, no large variations occurred and the sheaths were supplied by makers of refractory material, and this was taken to be their ordinary product. The remark which Dr. Hanson had made in the course of the discussion on the heat evolution which occurred on adding aluminium to nickel was a very interesting one, and one upon which they would have liked to have Dr. Gwyer's views. Mr. Stockdale's changes in regard to the copper-aluminium alloys did not bear very closely upon their determinations; they were, however, prepared to accept his figures in the matter of the alloy containing 14 per cent. aluminium and no nickel.

THE INNER STRUCTURE OF THE CRYSTAL GRAIN.

The third paper taken at the meeting on Thursday morning dealt with "The Inner Structure of the Crystal Grain as Revealed by Meteorites and Widmanstätten Figures," contributed by Colonel N. T. Belaiew, who gave an admirable exposition of the subject to the members. It described various octahedral sections and emphasised their relation to the Widmanstätten figures; it further described a method for the determination of the position of a secant plane in space, with reference to the angles. It also showed the application of the method to the case of the author's alloy No. 8 with the well developed Widmanstätten structure, and gave a diagram of a section with about 20 grains variously oriented. The importance of the method for the crystallography of metals was emphasised, and the suggestion made that the occurrence of Widmanstätten figures in metals crystallising in the regular system was associated with the face-centred cubic lattice.

Professor Carpenter called the attention of the meeting to the unique character of the paper, one also of great importance, which opened up a wide field of knowledge and study, whose limits it was impossible to see. The author could speak with great authority on the subject since he was the first to produce Widmanstätten figures artificially. A point of great interest in the paper was the relation found between the Widmanstätten figures and the octahedral structure, beautifully illustrated by micrographs and diagrams. The author had raised the question as to whether there was any relation between the axial planes of neighbouring grains or, as it was usually supposed, was the orientation of various grains quite independent? He was quite right, Professor Carpenter added, in raising it; its investigation would show whether there was some influence exerted between adjacent grains, which might not be improbable. Referring to a paper read before the Royal Society, Professor Carpenter said they had not observed Widmanstätten figures on the crystals therein dealt with. Aluminium crystallised as a face-centred cube and when distortion took place the slip started on a octahedral plane. The Institute was greatly indebted to Colonel Belaiew for putting before the members the record of a striking and novel research.

HARDNESS OF COPPER.

The next papers taken were two in number, by Mr. A. L. Norbury. The first, on the "Hardness of Annealed Copper," gave information on a research made by the author to obtain a more definite expression for the Brinell hardness of copper; his results for various copper alloys were tabulated and illustrated. The second dealt with "The Hardness of Certain Copper Alpha-Solid Solutions," and gave the hardness measurements of copper alloys containing various percentages of aluminium, silicon, manganese, nickel, zinc, silver and tin in solid solution.

Mr. O'Neil said he had worked on practically the same lines as the author and also found that the Brinell number rose as the load increased; it rose, passed through a maximum and then fell again. He announced that a paper would be read before the forthcoming meetings of the Iron and Steel Institute dealing with scleroscope and Brinell tests of steels.

Mr. J. S. G. Primrose (Manchester) congratulated the author on going a long way to establish the usefulness of carefully conducted hardness tests to the copper workers. Few ordinary experimenters took such care as the author to prepare the surface to be tested, and this care was amply justified by the results. The author was too brief in his description of the machine he used and he (the speaker) thought an improvement the author had suggested to the hardness testing press would be better understood by the members if fuller information were added. Not every practical worker possessed such a machine, free from inertia errors.

The members could refer for details of the principle of the machine used for determining Brinell hardness to the Proceedings of the Institution of Mechanical Engineers for October, 1920, page 936. The method of making concentric imprints mentioned by the author was not usual in works and seemed to give anomalous results in that the values of the hardness after a total of 3½ minutes application of the load should be the same as the full load for only 30 seconds. The author recommended the use of Meyer's formula to give a simplification of the hardness number; this many people were only just beginning to appreciate was not merely a number but a load value expressed in kilogrammes per square millimetre, similarly to tons per square inch in compression tests.

Dr. F. Johnson, dealing particularly with the first paper, said it contained very good material to work with. He asked whether the author had come across copper sulphide in his experiments, since he (the speaker) had found difficulties in connection with this. He showed by diagram how the Brinell hardness may decrease with an increased load, and asked whether the author had tried forging his cathode copper before melting.

In reply to the discussion, Mr. Norbury said he was interested to hear that Mr. O'Neil had obtained similar results to his own. In reply to Mr. Primrose, he thought the workmen could be educated in the method of testing referred to and given tables to aid them in the testing operations. In the matter of copper sulphide, there might have been some present, but in very small quantity; he was interested in the proposal to forge the cathode metal before melting it. The log $a + n$ values were the same for all the specimens of copper, and he had endeavoured to connect them with the ultimate stress.

THE SCLEROSCOPE HARDNESS TEST.

The first paper taken on the afternoon of Thursday, the 8th inst., had reference to "The Scleroscope Hardness Test and a New Form of Magnifier Hammer," by Mr. R. Genders, who read it in abstract and showed the instrument. It pointed out the lack of agreement which existed between the magnifier hammer readings in different scleroscopes, due to slight variation in the contour of the striking portion of the hammer nose. A new form of magnifier hammer had been devised, in which constant contour of the nose was ensured by using a hardened steel ball. The 3 mm. steel ball was suggested. Slight variations in the weight of hammers were found to have very little effect on the rebound. The relation between the ball or magnifier and universal hammer readings was not constant for all materials, and calibrations should be carried out on material similar to that to be tested if there were any considerable error in the hammer calibrated.

The discussion was opened by Dr. Greaves, who congratulated the author on his useful development of scleroscope testing. Trials made by a number of observers with the 3 mm. ball gave concordant results and showed great promise for the new hammer—so far as could be judged this had already secured a useful stand, and would find its application for specification purposes.

Dr. Gwyer found the author's scleroscope a valuable instrument; it would be still more valuable if there could be eliminated from it the defects defined in the present paper, and in a previous one by Mr. Tritton (see ENGINEERING, vol. cxii, pages 483 and 492). The idea of using a ball appealed strongly to him (the speaker); it would greatly increase the range of usefulness of the instrument. All depended upon standardisation; a standard hammer was required, and in this connection Dr. Gwyer asked whether the author had already approached makers of such instruments.

Commander Venner stated that he had been

associated with the author in making tests on Admiralty brass and could say that the ball hammer was a decided improvement on the one used formerly. The old hammer had varying contours. He (the speaker) was attracted by the improvement which was distinctly evidenced.

Mr. F. J. Tritton thought the author had perhaps overlooked the ease with which the magnifier hammer could be rectified so as to give the correct rebound. As long as the correct rebound was obtained there was not much to choose between the ball or the older hammer. He emphasised the advantage of resorting to a greater number of better selected hardness test-blocks.

Mr. W. B. Clarke, with reference to the obtaining of glass tubes of equal diameter throughout, said these could be ground out and polished inside to within a very minute fraction of an inch, at a comparatively low expenditure, and this would obviate the difficulties encountered due to air friction.

In the course of his reply, Mr. Genders said the makers had not been approached, but the description of the scleroscope had been given in technical journals, where the makers could see it; previous to approaching them, he had deemed it preferable to read the present paper before the Institute. The making of the hammers was most easy and he was certain they would give the results which the paper described. A standard test-block was not in existence. Shore had none, and that probably explained why the hammer was turned out in such large quantities. He did not think that repointing was a solution to the problem, even were there a standard test-block. The accurate fitting in the tube did not give much trouble. Here the author exhibited a number of test-blocks prepared from round bars, and recommended giving them a hexagonal or dodecagonal section in order to obviate their being used in an emergency for other purposes. When he found the scleroscope glass tube had something wrong with it, he changed the tube, the instrument then gave good results, thus confirming that the tube was to be incriminated.

Cast Copper-Tin Alloys.

The second paper taken on Thursday was by Mr. Harold Heape, on "The Density and the Hardness of the Cast Alloys of Copper with Tin." In reading it in summary the author stated that two important properties of the alloys of copper with tin had been determined, namely, the density and the hardness, and in general it appeared that the hardness varied with the density. The author's conclusions were the following: The algebraic sum of the changes in volume, occurring on alloying and during subsequent solidification, was in every case negative; or, in other words, resulted in contraction. Though the density and the hardness were related, it was not possible to determine the exact relationship by means of determinations made on cast alloys. The hardness curve obtained by the author did not fit in with the hardness theory of Kurnakow and Zemczuzny. It was very difficult to obtain sound castings with the copper-rich alloys.

Professor Turner emphasised the fact that one could not determine the constitution of a series of alloys by studying only one feature, such for example as the melting-point. On the study, the rate of cooling also came in, and the tests had also to include chill and sand casting.

Dr. Haughton, referring to the density curves and Brinell hardness curves obtained by the author, found that in the neighbourhood of 100 per cent. of copper the density results seemed to be more erratic with the chill-cast than with the sand-cast specimens. The author had said that the points of contact of the curves, at 30 per cent. copper and 8 per cent. copper corresponded with the points of zero expansion recorded by him (the speaker), though the zero point at 60 per cent. copper was not confirmed. He (the speaker) would look up the matter, but was understood to say, that another researcher's results fitted in with the author's rather than with his (the speaker's). In regard to the casting of the alloys from a temperature equal to 8 per cent. above their respective melting points, he asked whether this melting-point was expressed in degrees absolute or in centigrade. Copper alloys above 50 per cent. required a heavy heat treatment, and the author had done well to call attention in his paper to the fact that the conditions under which the tests were made were so different from every-day practice that his results could be of little use to the founder.

Dr. Hanson thought it was going too far for the author to say that the hardness curve he obtained did not fit in with the hardness theory of Kurnakow and Zemczuzny, for the latter had obtained on that theory very beautiful alloys.

Mr. Heape, in his reply, said that the 8 deg. above the melting-points were in Centigrade, and he adopted the figure as he was under the impression that it represented works practice. It took months, he added, to get the alloys in a state anything like equilibrium. He had not the least desire to cast any aspersion on the work done by the last-named researchers, all he wished to say was that the hardness curve he obtained did not agree with their hardness theory.

Alloys of Aluminium and Copper.

The third paper had for its title "The Heat-Treatment and Mechanical Properties of Alloys of Aluminium with Small Percentages of Copper," by Dr. D. Hanson and Miss M. L. V. Gayler. We reproduce it on page 343 of the present issue.

Dr. Haughton said he was struck by the high point of the curve relating to the 4·5 copper alloy (Fig. 4), and asked whether the authors were quite convinced that it reached the high point shown at 160 deg.

Dr. Gwyer found remarkable the improvements shown in the properties. Some time ago he had an 8 per cent. copper alloy which he heat-treated for 12 hours at a temperature of 510 deg., and found an improvement in the shock resistance, but not much improvement in the tensile. He asked how the properties of the authors' heat-treated alloys compared with the "Y" alloy.

Mr. W. B. Clarke stated that several years ago, and with reference to a nickel alloy, he used brass moulders' sand and then iron moulders' sand, when both gave trouble. He had the sands tested and found they contained impurities. New sand also gave bad results, but after heat-treating the new sand the results were good. In work of this nature, it was safe to do so. For chill castings he heated the moulds up to 600 deg. or 700 deg. C., when the results were much better than with sand castings. He asked how the authors' alloys were air cooled, on the floor or suspended? When he (the speaker) annealed copper tubes and put them on the floor they cracked when swaged; when, however, he suspended them for cooling he got over that trouble entirely.

In replying, Dr. Hanson said he did not claim that the results shown in Fig. 4 were absolutely typical of the 4·5 copper alloy; the point represented probably one of the larger variations, and he had not checked the figures over again. In regard to Dr. Gwyer's failing to get good tensile results with his 8 per cent. copper alloy, this could be explained by the fact that all the $CuAl_2$ did not go in solid solution and the alloy was hence weaker. The authors had completely dissolved the $CuAl_2$. They had not tested the point on larger castings, but it was possible that the effect would be produced as a result of slow cooling. All the specimens were very heavily chilled in cast-iron moulds, the ratio of mould to metal being 7 to 1. The cooling was on the floor, and possibly some strains were produced by cooling in that way.

Alloys of Aluminium with Magnesium and Copper.

The fourth paper dealt with "The Constitution and Age-Hardening of the Ternary Alloys of Aluminium with Magnesium and Copper," by Miss M. L. V. Gayler, who read it in abstract.

Among other points, it stated that at a temperature of 400 deg. C. copper was practically insoluble in aluminium in the presence of magnesium. Alloys of aluminium with low percentages of copper and magnesium did not possess the property of age-hardening after quenching from 400 deg. C.

Dr. Hanson stated that this was another stage in the very comprehensive series of investigations by Miss Gayler. Her results were very instructive, and the agreement between the mechanical properties and age-hardening was very complete. The aluminium available contained a small percentage of silicon, this caused discrepancies; what was wanted to make the results still more thorough was silicon-free aluminium.

Dr. Haughton complimented the author on her admirable micrographs; he also questioned whether in the structure diagrams the lines joining at a point alpha should not be rounded off at that part of the structure. Silicon was the bugbear of the author; he (the speaker) found that to be the small percentage of iron present.

Miss Gayler confirmed the difficulty of obtaining absolutely pure aluminium. The microsections under the microscope were admirable, having various tint effects which the photographs could not render, and yet the photographs were better than the reproductions in the paper. She agreed with Dr. Haughton's remark in the matter of the structure diagrams.

The last paper was taken as read. It had for its title "The Oxydation of Metals at High Temperature," by Mr. N. B. Pilling and Mr. R. E. Bedworth, East Pittsburgh. Mr. E. A. Bolton congratulated the authors on their new line of research work with non-ferrous metals, which for the moment might be called of theoretical interest only; it would, however, soon be found useful in practice. He was interested in the oxidation of the brasses; in these there was a vapour pressure from the zinc, and it was very important to ascertain what oxide, whether zinc oxide or copper oxide was formed.

May and Autumn Meetings

It was announced that the May lecture would be delivered on May 2, at 8 p.m., at the Institution of Mechanical Engineers, by Dr. W. Rosenhain, F.R.S., his subject being "The Inner Structure of Alloys." The autumn meeting is to take place in Manchester on September 10 to 13.

Thanks to the various members for their contributions and to the Institution of Mechanical Engineers for the kind loan of their premises concluded the proceedings.

NOTES ON NEW BOOKS.

The publication of a second edition of "*The Analysis of Non-ferrous Alloys*," by Fred Ibbotson and Leslie Aitchison, (London: Longmans Green and Co.; price 12*s.* 6*d.* net) proves that it has fulfilled the purpose of the authors in writing it, namely, to give in a concise and convenient form the most recent and accurate methods for the analysis of non-ferrous alloys. In the new edition few changes have been made in the text, but there have been new additions relating mainly to the analysis of aluminium and its alloys. Such alloys, as is well known, have developed greatly through the demand for aircraft material, although the methods of analysis have hardly kept pace with the improvements in their manufacture. Considerable space is devoted to a discussion of electrolytic methods now so much in vogue, and the theoretical basis for successful separation of mixed ions is explained with great clearness. In addition to the methods employed in the estimation of single elements the complete analysis of the common commercial alloys, such as brasses, bronzes, German silver and the white metal alloys are given fully, and this section completes what is unquestionably the most reliable book on the subject yet published.

Considering that text-books on calculus generally demand a special volume of their own, it seems almost futile to condense into one volume the whole domain of mathematics for the engineer, comprising algebraic analysis, analytical geometry, trigonometry and vector analysis, together with an exposition of numerical and graphical methods which are frequently too much neglected in such works. Professor H. E. Timerding has made this attempt in a large octavo volume of 272 pages, bearing the title "*Mathematik*" (Berlin, Julius Springer; price 6*s.* 8*d.*). The volume belongs to the series of the Handbibliothek für Bauingenieure, edited by Professor R. Otzen. To discharge his task, Professor Timerding has had to content himself with giving an outline of the deductions or with indicating the arguments which will lead to certain results. In criticising a work of this kind the reader really ought to put himself in the place of the student who looks for guidance in his studies. The volume is especially written for the engineering students at the Technical High School of Braünschweig, where Dr. Timerding is teaching. The mention of this fact does not imply adverse criticism, and we should point out that the treatment is abstract and not associated with definite

problems. The introductions are sometimes, perhaps, a little too sketchy in character, particularly when we consider that the book is not intended for the advanced student; there the lecturer has to step in.

The fourth volume of the fourth edition of "*A Dictionary of Applied Chemistry*," edited by Sir Edward Thorpe, C.B., F.R.S., dealing with the letters L, M, N and O down to oxydisilin, is technically very important, since it contains the articles on lead, napthalene, nitrogen, oils and fats, &c. Ample space has been granted to these subjects, but, as in the preceding volumes, the sections are of unequal merit. The article on lead has been rewritten and enlarged by Dr. J. A. Smythe, and new diagrams have been added. We have not noticed any change in the article on lakes, not even in literature references. To the section on lava, Dr. L. J. Spencer, who has contributed a good many other sections, devotes only one page instead of the three pages of the third edition; that is sufficient, though mention should have been made of volvic lava, which has become an important acid-resisting lining. The article on lithium is little changed, naturally; a literature reference might have been added to the remarks on the peculiar electrolytic behaviour of lithium hydride, about which a good deal has been written of late. The third volume of this edition did not, we should say, contain a general section on hydrides. The articles on nitrogen and on atmospheric nitrogen have found very able compilers in Messrs. J. R. Partington, E. Hart (of Easton, Pennsylvania), and F. C. Zeisberg (of the du Pont de Nemours Company); we notice references even to the Rutherford bombardment of nitrogen by α particles and to the revision by Moles, 1922, of the density of nitrogen. On the other hand, the long article on oils and fats is substantially as Dr. J. Lewkowitsch left it in 1912, and Mr. C. A. Mitchell, who has revised the article, as we see from the list of contributors, has not added his initials to those of J. L. No doubt, Dr. Lewkowitsch had well discharged his duties; but the oil industry has not stood still in the past decade. The former section on hydrolysis has been out out, and the discussion of the effects of air on oils has been extended; but we find remarks on recent foreign competition bodily reproduced, and the final six pages of tables reappear in the old form. Elsewhere there are welcome new entries, mostly good, though unsigned. In some parts, however, more might have been done to justify the claim to a "revised and enlarged edition." The term "Lignone" certainly deserved notice; but the word is missing. The dictionary is published by Messrs. Longmans, Green and Co., and the price of this fourth volume is 60*s*.

The intimate relation existing between the macrostructure and microstructure of any given alloy is illustrated in a most satisfactory manner in "*Crystallisation of Metals*," by Colonel N. T. Belaiew, C.B. (University of London Press, Limited; price 7*s*. 6*d*. net). Four lectures delivered by the author at the Royal School of Mines, London, form the basis of the book, and the subject is dealt with purely from the theoretical point of view. Having discussed the primary and secondary crystallisation of steel, the author passes on to the detailed consideration of the inner structure of crystalline grains as revealed by meteorites and the Widmanstätten structures. By means of mathematics it is shown that the structure of the crystalline matter in every grain and the orientation of one grain with reference to another is made perfectly intelligible and accessible to direct measurement. Some excellent photomicrographs of pearlite under very high magnifications are given, and the all-important effect of under-cooling on the production of eutectics is fully emphasised. The last lecture is devoted to spherodisation in eutectics and especially the formation of globular pearlite, the author concluding by briefly alluding to the Damascene process. The work is advanced in character and is highly technical throughout and, as befits a talented research metallurgist, the numerous photo-micrographs and macrographs given are, it is no exaggeration to say, excellent. The preface written by Professor H. C. H. Carpenter, F.R.S., undoubtedly enhances the value of the book.

Complaint is frequently made that "specifications" are so loosely drawn and phrases so vaguely used, that the interest of neither the client nor the contractor are adequately protected. This inconvenience is the more likely to occur where trade customs vary, new markets are opened, and fresh sources of supply tapped, for the old phraseology is maintained in spite of changing conditions. The timber trade offers a good example, for here the descriptions of material vary with locality, and the scientific description does not coincide with the commercial. Recognising the need for distinct and intelligible wording that will express what an architect requires and what a contractor is willing to supply, a little book has been issued by Mr. James Davies and others, that aims at correcting current errors and disseminating precise information concerning the commercial use of timber. ("*The World's Timbers*," by James Davies. London: Alf. Haworth and Co.; price 5*s*. net.) Of course, within a small space there is no room for botanical description, and only a few woods, such as deal and pine, are treated with any approach to fullness, and in these cases, the treatment is more especially directed to pointing out the principal defects, indicating what may be tolerated and what call for rejection. The use of such phrases in specifications, as "Free from sap, shakes, large and loose knots and all other defects," has little meaning. The supply of perfect timber is very small, and the cost so prohibitively high, that there is no attempt on the one hand to provide, or on the other to enforce, a quality that would meet such a standard. There is a manifest absurdity in using one stereotyped phrase to describe the timber best adapted for cathedral or cottage, for factories or dwelling houses. The author, therefore, makes some practical suggestions, and offers some working formulæ that will convey the architect's intentions and protect his clients interests. The remarks on ports and shipments and on the representative brands in use should be of practical utility. Another service this little book might render is to call attention to the number and character of many beautiful woods that are being grown in India and the Colonies, that are well adapted for furniture, panelling, parquet flooring, and a variety of other purposes. Many people think that teak is the only timber of importance produced in India, and that Jarrah and Karri exhaust the woods of Australia.

Professor Hugo Fischer's "*Allgemeine Maschinenlehre*" covers the ground of an English treatise on general applied mechanics, but goes more fully into certain developments than elementary books of this kind usually do. The volume of 228 pages (Leipzig, Otto Spamer; price 6,300 marks plus 200 per cent.), is, however, not intended for advanced students. The book is based upon the course of lectures which Professor Fischer has been delivering at the Technical High School of Dresden, and it is not quite free from the drawbacks common to such compilations. Thus we read that water meters of the vane type are subject to a mean error of 1·5 per cent. or 2 per cent.; the authority quoted is Salbach, 1876. The description of the Parsons turbine is taken from an article which appeared in our columns in 1892; some subsequent developments of the turbine are mentioned, but it might have been better to select a later article. In many cases, on the other hand, novelties of recent years are duly noticed, and the general arrangement, the concise, clear exposition, the many (200) illustrations, though only explanatory diagrams, and the good index deserve commendation. Professor Fischer does not indicate the number of terms which his students should be able to devote to the study of his "Maschinenlehre"; his lectures probably extend over both the terms or semesters of the first year's course.

An interesting book in French, on tides and their industrial utilisation, explaining—as far as they can be explained—the undulatory motions of the oceans, the formation and propagation of tides, is entitled *Les Marées et leur Utilisation Industrielle*." The latter portion of the book dealing with the utilisation of the tides for power production is that which will most appeal to engineers. It reviews the difficulties of the problem in every aspect, and will be read with a certain amount of regret by all who, not fully familiar with the subject, had entertained high hopes that the power derivable from tidal action was likely, without any great expenditure, to meet every requirement and to lead forthwith to great saving in fuel consumption. Thus, for example, the author states that at Granville, on the French Coast, where the highest tides occur, a 20,000-ton battleship acting as a float would hardly be able to yield sufficient power to drive a 100-h.p. engine even at exceptionally high spring tides, and on certain days of the year the power would be a quarter of this figure. In the present state of knowledge, the utilisation of the power available in the tides is obviously by means of reservoirs in series, so built as to be regular in their operation—and regularity is difficult of attainment—the differences in the head of water being turned to account for driving turbines both in filling and in emptying the reservoirs. But in the case of the reservoirs, although suitable turbines are now available, the design of the requisite sluice valves is surrounded with many difficulties; the working of the reservoirs may, further, inconvenience navigation in neighbouring passes by interfering with the normal drifting of the sands. Conditions vary with every locality, and no fixed rules can in any way be laid down. The criterion is the price at which the kilowatt-hour can be sold, and, the author states, the difference between the selling price of current produced by steam, oil or gas engines, and that of current produced in hydraulic stations, has a tendency to decrease; and even in districts where water power is available there seems to be an inclination to revert to small independent power stations equipped with fuel engines, the first cost of which is comparatively low. Nevertheless, there remains an inexhaustible reserve of power in the oceans, and the problem of finding a suitable plant for its utilisation remains a task for the inventor. The book is well written; like many Continental books, however, it lacks an index to facilitate reference to its contents. The author is Mr. E. Fichot, Chief Hydrographer, French Navy; the book is published at the price of 9 francs by Messrs. Gauthier-Villars and Co., 55, Quai des Grands Augustins, Paris.

Under existing conditions the presentation of data relating to naval vessels is complicated by the fact that the Washington Treaty has not yet been ratified and that, except in the case of Great Britain, the scrapping of capital ships agreed upon under the terms of the Treaty has not been fully carried out. It is difficult, therefore, to decide which ships to exclude from and which to retain in, any list of vessels owned by the various signatory Powers. In *Jane's Fighting Ships*, which has just been issued, the editor, Mr. Oscar Parkes, has included all battleships and battle cruisers which still exist as fighting machines, although earmarked for scrapping, but has omitted vessels upon which the work of construction has been suspended; this is probably the most reasonable course to adopt in the present circumstances. As the book has now reached its twenty-fifth year of issue, we may assume that the general character of its contents is widely known, but we may say that it gives data on the construction, armament, armour, machinery, &c., of all types of naval vessels belonging to all countries of the world, with outline diagrams, photographic illustrations and silhouettes of practically all of them; it is in fact, rightly described as an illustrated encyclopedia of the world's navies. No information is yet available regarding the two new capital ships in hand in this country, but some illustrations, reproduced from drawings by the editor, of the aircraft carriers Eagle and Hermes are included, these being the most important items of new construction as far as Great Britain is concerned. An official sketch of the proposed design for the United States aircraft carriers Lexington and Saratoga is also included, and interesting comparisons may be drawn between these vessels and the British ships. We note that, in the current volume, the countries are arranged in alphabetical order, and not in accordance with their relative naval strengths or geographical positions as was the case in former issues. The new arrangement certainly tends to facilitate reference, as also do a list of contents and a general index to the names of all vessels irrespective of type or nationality. The whole of the information given, we understand, has been carefully revised, and many new illustrations have been included. The work is published by the Sampson Low, Marston Company, Limited, 100, Southwark-street, S.E., at the price of 2 guineas net; it contains 426 pages, strongly bound in blue-cloth covered boards.

THE PLUTO MECHANICAL STOKER.

MECHANICAL stoking is, of course, the accepted practice in all boiler plants on land except those of comparatively small size, but there is great diversity of opinion as to the best type of stoker for general use. It is likely that unanimity will never be reached, for the question so largely depends upon the nature of the fuel to be burnt and the conditions under which the stoker has to operate. The operating costs of a stoker in respect not only of the upkeep of its own mechanism, but of the maintenance of the arches and brickwork of its setting introduce a further, and highly important factor in the decision as to the best type to instal. In the illustrations on pages 326 and 327 we show the arrangement and details of the Pluto stoker, developed by the N. V. Maatschappij Pluto, of Nijmegen, Holland, whose agents in this country are Messrs. Power House Components, Limited, of Albion Chambers, King-street, Nottingham. Stokers of this kind are in successful use in the large power station at Amsterdam, and elsewhere on the Continent.

The arrangement of the Pluto stoker as applied to a water-tube boiler of the "Clayton" type is shown in Figs. 1 and 2, on page 326. The grate is in two sections, the front part being inclined downwards from the hopper and the back part horizontal. Both sections of the grate are formed of long narrow bars having a horizontal reciprocating motion. The object of the horizontal section of the grate is to reduce the speed of travel of the fuel as it burns, so that the ash and clinker accumulate at the back of the furnace, and have ample time for their combustible contents to be completely burnt before falling over the end of the grate. The setting comprises a very short front arch, and a larger rear arch which reaches almost to the front of the ash bars, as the horizontal portion of the grate may be

THE "PLUTO" MECHANICAL STOKER FOR STEAM BOILERS.

CONSTRUCTED BY THE N. V. MAATSCHAPPIJ PLUTO, NIJMEGEN, HOLLAND.

Fig. 1.

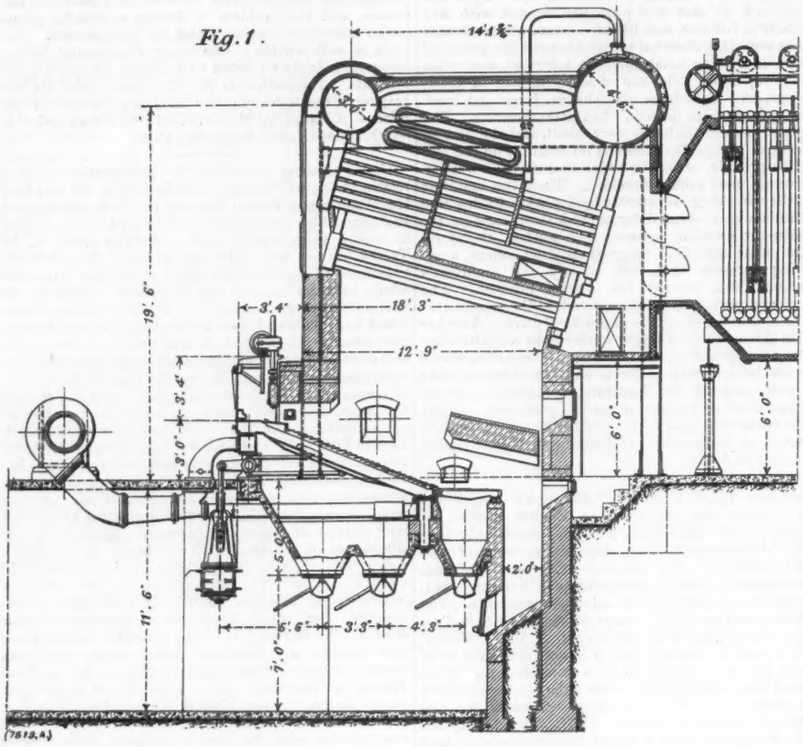


Fig. 2.

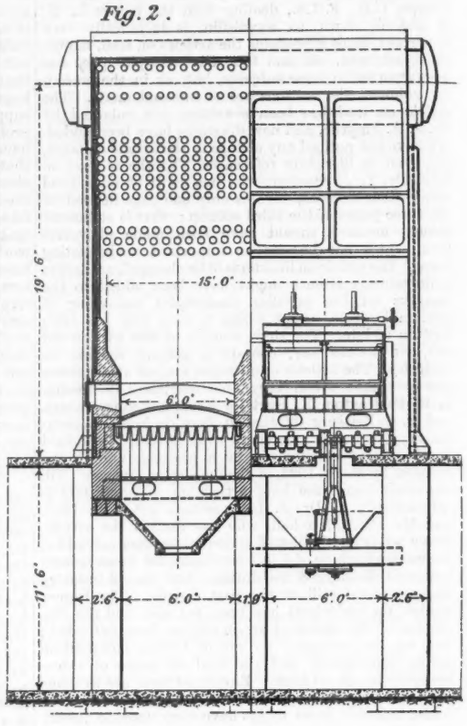


Fig. 3.

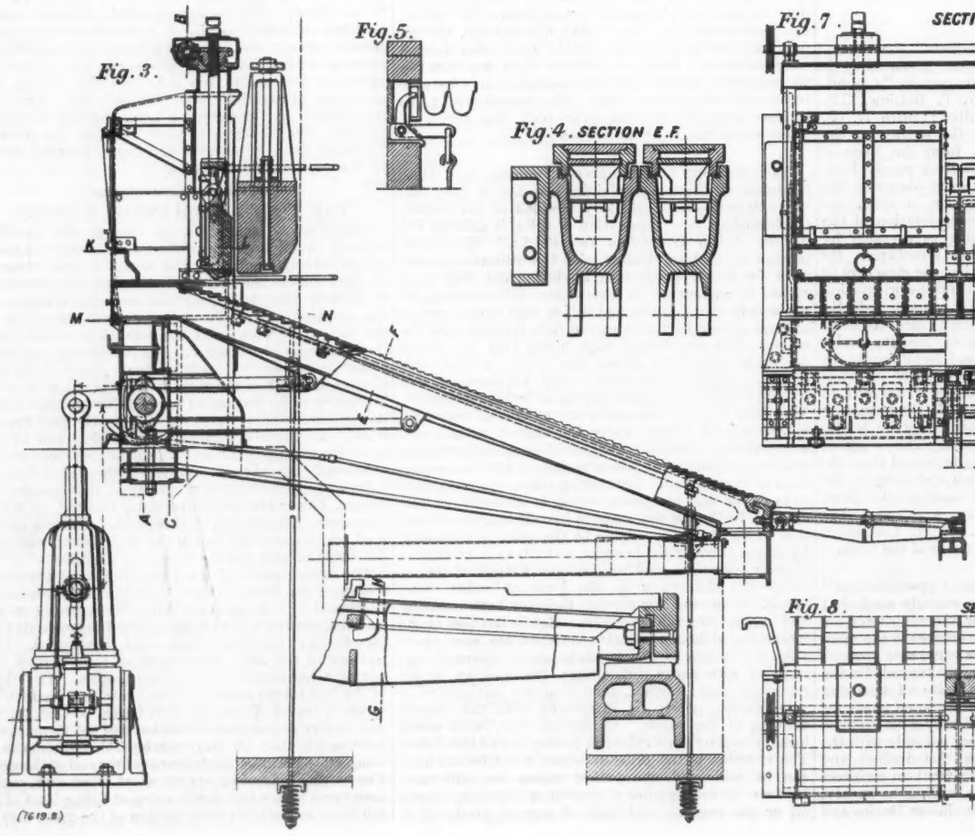


Fig. 5.

Fig. 4. SECTION E.F.

Fig. 7.

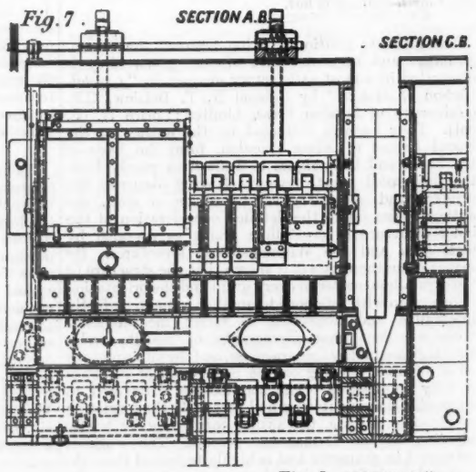


Fig. 6. SECTION G.H.

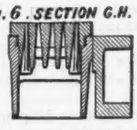
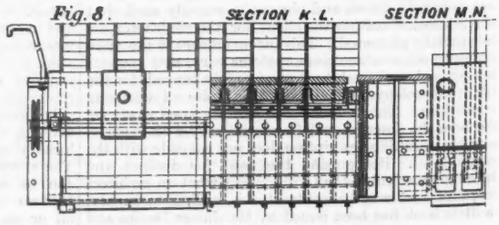
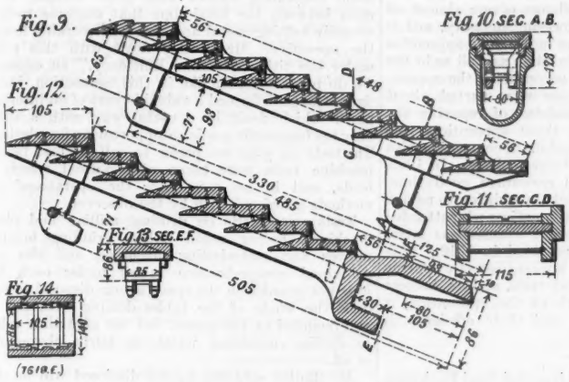


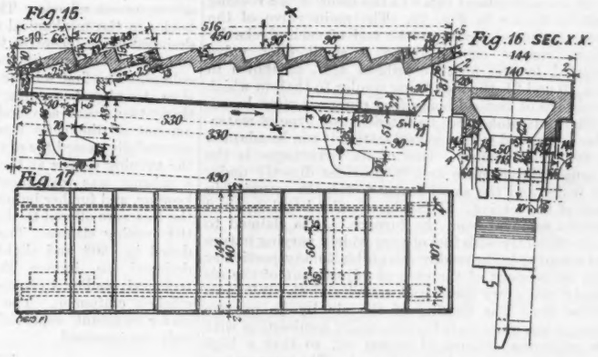
Fig. 8.

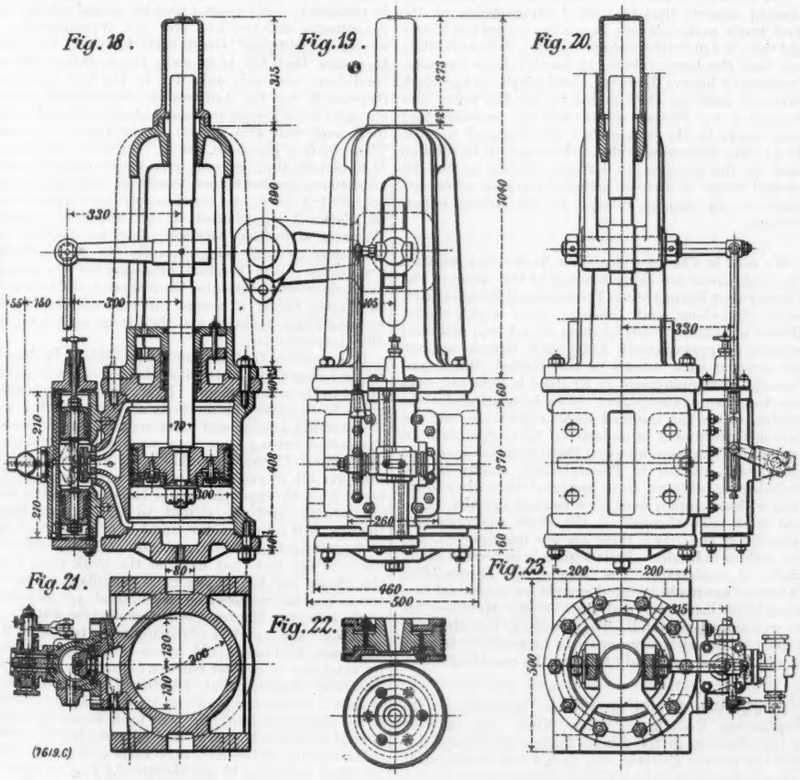


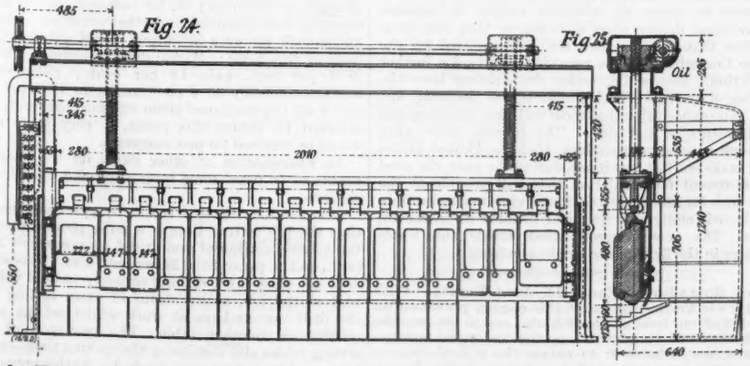
THE "PLUTO" MECHANICAL STOKER FOR STEAM BOILERS.

CONSTRUCTED BY THE N. V. MAATSCHAPPIJ PLUTO, NIJMEGEN, HOLLAND.









termed. This rear arch serves to ensure the complete combustion of the fuel. Such riddlings as fall through the inclined portion of the grate, being largely composed of fine coal and cinders, are worth saving and returning to the fires. To enable this to be done they are arranged to fall into a hopper beneath, separately from the ashes which fall through the ash bars. Such clinker as may be formed passes over the ash bars and falls into a third chamber, whence it can be removed by a door in the basement wall.

The stoker works with forced draught, air being supplied by the fan as shown in Fig. 1. The air supply is divided, part passing down through the inclined grate bars and issuing beneath the fire through holes in the renewable fire bars, which will be referred to later. The remainder is led under the horizontal section of the grate and passes up through the ash bars. The air supply can be regulated by means of adjustable dampers, and the amount delivered to the back end of the grate reduced to the minimum necessary for completing the combustion. The horizontal section of the grate can be worked entirely with natural draught if required. On the upper portion of the inclined portion of the inclined bars little air is needed, because here the coal is merely dried and ignited, but on the lower portion the combustion is very active, diminishing as the fuel travels on to the horizontal bars. The ports through which the air enters the fire are therefore designed to give a supply in accordance with these conditions.

The grate bars, both inclined and horizontal, slide on three cast-iron transverse air boxes. The inclined bars consist of hollow troughs machined on both sides and on their sliding surfaces, and carrying on their upper sides, small and easily-renewable standard fire-bars. The construction will be understood from Fig. 4, which shows a section through a pair of adjacent bars. The lugs seen beneath the troughed grate bars are for connecting the bars to the rocking shaft which drives them. Fig. 5 shows the device used for keeping the bars in close contact so as to prevent air leakage between them while permitting movements due to expansion and contraction. The finger-pieces which press the bars together are held to their work by rods kept in tension by helical springs, as shown in Fig. 3. Fig. 6 gives a section through the horizontal ash bars, part of which are shown in side elevation in the lower part of Fig. 3.

The arrangement of the front of the grate is shown in Fig. 7. The fire door consists of a number of brick-lined castings hanging from a horizontal rail, the whole being raised and lowered to provide for different thicknesses of fire, by means of the worm and screw gear shown. The fire door is illustrated by itself to a larger scale in Figs. 24 and 25, annexed. Horizontal sections of the furnace front are given in Fig. 8. Referring again to Fig. 3, it will be noticed that behind the fire door just referred to is a large firebrick sluice also arranged to be raised and lowered. This is fitted only in installations where there is sometimes occasion to burn very low-grade fuel indeed. In such cases the sluice is opened and a correspondingly thick fire obtained.

Details of the renewable fire bars are shown in Figs. 9 to 17. The earlier figures refer to the bars which form the greater part of the inclined portion of the grate, extending from near the top down to the commencement of the ash bars. They fit in the trough-shaped grate bars, as already mentioned, and are stepped and perforated as shown. The fire bars used on the upper part of the grate are illustrated in Figs. 15 to 17. These have no perforations for reasons already given. The reciprocation of the fire bars, both inclined and horizontal, is effected by a rocking shaft running across the front of the grate. Short levers on this shaft are connected to the lugs beneath the grate bars by means of links. The shaft is caused to rock by means of a hydraulic motor, the whole arrangement being perfectly clear on reference to Fig. 3. Both the speed and the amount of travel of the grate bars can be easily regulated.

The hydraulic motor, illustrated in Figs. 18 to 23, is an interesting feature of the Pluto stoker. It can be worked by water either from the boiler feed pumps or from other pumps specially provided for the purpose, the latter method being usually adopted in large

stations. The pump cylinder is about 12 in. diameter. When the motor is arranged below floor level, as in Fig. 1, the drive to the rocking-shaft lever is from an extension of the piston rod; in other cases, when the motor is on the firing-floor level, head room is saved by a crosshead drive to the lever of the rocking shaft as shown in Fig. 19. The main valve of the motor is moved across at the end of each stroke by water pressure controlled by a small pilot valve operated by the pump crosshead arm, as shown in Figs. 20 and 21, the idea being similar to that on which the design of vertical boiler-feed pumps is often based.

The Pluto stoker can be fitted to any type of water-tube boiler, and with a special setting it can be adapted to cylindrical boilers. One of its advantages is the unusually large grate area it provides directly under the boiler and the small amount of space occupied in front of the setting. It can be examined and repaired without removal from the furnace. It is claimed to work efficiently with fuel of very widely varying nature and quality, being readily adaptable to any particular kind on account of the ease of adjustment of the air supply, the grate speed and travel and the thickness of the fire. The heating of the air by its passage through the grate bars favours ready combustion with the minimum amount of excess air, so that a high furnace efficiency can be maintained. The temperature of the grate bars is also lowered by the continual passage through them of cold air, and their durability is therefore increased. The grates are made in widths ranging from 4 ft. 11 in. to 8 ft. 10 in., and in lengths from 6 ft. 6 in. to 13 ft., measured on the inclined portion. The horizontal ash-bars vary from 1 ft. 8 in. to 6 ft. 6 in. according to the class of fuel to be dealt with. The rate of combustion with normal bituminous coal is about 30 lb. per sq. ft. of inclined grate, but this can be more than doubled with lignite as fuel. Semi-bituminous slurry from washeries can be burnt at the rate of 24 to 25 lb. per sq. ft. The grates will burn coke mixed with about 10 per cent. of bituminous coal, and even coke breeze alone is being used in some cases. The representative of the Pluto Stoker Company in London is Mr. J. E. O'Breen. of 2, Upper Westbourne-terrace, W.

INDUSTRIAL NOTES.

A STATEMENT to the following effect was issued a few days ago by the Mining Association of Great Britain, with reference to recent remarks by Mr. Robert Smillie:—

According to the published reports, Mr. Smillie is concerned at the reduction of wage rates for the current month, in view of what he describes as the increasing output and the rise in profits to 2*s.* 3*d.* per ton. It can only be assumed that Mr. Smillie is labouring under a misapprehension. There was an increase in miners' wages rates in Scotland for January and February from 111·11 per cent. on the base rates to 125·4 per cent. It is true that there has been a very slight decrease from 125·4 per cent. to 124·19 per cent. in respect of the current period, but there has also been a decline in profits. The joining of November—a good month—with December—a poorer month, on account of the holidays—has resulted in a decrease of only ¾*d.* per shift, which has been accompanied by a reduction of profits amounting to 1*d.* a ton.

Mr. Smillie made reference to the fact that all payments for employment insurance, National Health Insurance, and premiums in respect of workmen's compensation made by the mine owners are charged against working costs, and not against profits. This is a surprising statement to make at this late stage. Such charges have been authorised since the National Wages Agreement was first put into operation in July, 1921. The question of the owners' contributions to the two insurance schemes was referred to the independent chairman of the National Coal Board, who ruled that they should be admitted to the specified list of "costs of production other than wages."

In the matter of workmen's compensation insurance, the accountants of both sides concurred in recommending this as an admissible item of cost. This recommendation was adopted by the National Board, one-half of which is composed of miners' representatives.

With reference to questions recently asked in Parliament, the Mining Association points out that the profits of the mining industry for the eighteen months following decontrol amounted to 1*d.* per ton raised, without allowing for taxation or capital charges. The wages paid in the same period amounted to 181,466,000*l.* and under the agreement the owners were entitled to 22,400,000*l.*, whereas the gross sum actually received by the latter was 1,200,000*l.*, as compared with 21,100,000*l.* in the twelve months ended March, 1914. The Mining Association says it has already stated, and desires to repeat, that its figures and the method of compilation it employs are open to any accountancy test or audit that the miners' accredited accountants desire to institute.

We have received from the Central Marine Engine Works, West Hartlepool, particulars of their apprentice advancement scheme. The scheme covers almost all trades in the mechanical engineering industry, and is designed as an incentive to the industrious apprentice to attain proficiency in the workshop as well as in the college. The first scheme for encouraging the apprentices to attend evening classes was started about thirty-two years ago and consisted of repaying the amount of the class fees to those apprentices who successfully passed the examinations in connection with the evening classes at the technical college. In 1902, a scheme was introduced to encourage good time-keeping, and further inducements in addition to paying the fees were offered to those apprentices who attended the evening classes. The present scheme was introduced in 1908 and slightly modified in 1912; it is designed to induce their apprentices to pursue technical studies, to keep good time, and to become efficient craftsmen. The work of the apprentices is under constant supervision, and their efficiency is duly recompensed.

The secretary of the London Iron and Steel Exchange, Limited, reports that in several departments of the steel trade materials are becoming somewhat scarce and there is a definite shortage of iron. A feature lately has been the large volume of inquiry from overseas. Prospective buyers, however, particularly in the East, have not made up their minds to pay the prices now demanded by British works and fix unsatisfactory price limits to the orders they are prepared to give. As a result, numerous cabled orders have to be referred back to the prospective buyers. Owing to the increased range of British prices, American sellers are beginning to take an interest in the British export markets.

We read in *The Iron Age*, New York, that requests for employment are being received at the offices of the Employment Bureau of the Pennsylvania State Department of Labour and Industry from highly-skilled British mechanics, many of them expert iron and steel workers. Approximately 2,000 such British workers are arriving each month in the United States and Canada. Unemployment in England is reported, says our American contemporary, to be responsible for the exodus, which has assumed such proportions that the British Government is understood to contemplate an embargo. The men, many of them from Glasgow and the Clyde, arriving in Pennsylvania, chiefly in the Philadelphia district, have reported that they have been without employment for seventeen months. Iron and steel mills throughout the State are operating virtually at capacity; there are few unemployed, and the outlook is bright. Philadelphia is in need of many kinds of mechanics. The New York Shipbuilding Company has made heavy demands for structural iron assemblers, layers-out and shear men. Moulders are in widespread demand. The Reading Foundry and Supply Company was reported to be ready to take on any number of men ready to learn the moulding trade.

Immigration is still a problem, according to the *Engineering News-Record*, New York, but in view of the situation in the Senate there is no expectation that the present Congress will pass a new immigration law, and those industries which have been urging revision in order to insure an adequate supply of common labour must derive what consolation they can from the fact that they escaped the Bill reported by the House Committee. This provided clearly for further restriction. Meanwhile, under the existing laws the number of arrivals is higher than it was last year, but there is no expectation that these will meet the estimated requirements of industry. The journal adds that although it appears, therefore, that the United States must make shift as best it can during the year, the need still is urgent for regulation that will provide at the same time for needful restrictions and an assured supply of selected immigrants qualified to meet its industrial needs. The new Congress must tackle the whole problem in the light of acquired experience.

THE ROLLS-ROYCE EAGLE IX AERO ENGINE.—With reference to the description of this engine, published on page 212 of our issue of the 16th ult., and to the remarks which appeared on page 214, on the design and arrangement of the carburettor to reduce the risk of fire, we have since been informed by Messrs. Rolls-Royce, Limited, that when the engine is installed the air intakes to the carburettors project through the cowling of the machine, and are arranged so that they are self-draining. This entirely prevents any loose petrol from collecting in or around the engine installation, and thus still further reduces the possibility of fire.

THE LOAD FACTOR OF MACHINE TOOLS.

IN the course of an admirable paper on "Workshop Efficiency" which Mr. G. E. Bailey read before the Manchester Association of Engineers on the 2nd inst., some interesting figures were given relating to the ratio between the total time that machine tools are actually cutting metal and the total working hours of the operative. Mr. Bailey dealt with this subject under the title "Machine Efficiency," an expression we do not altogether like in this connection, but the figures he gave formed a valuable part of an interesting paper which dealt in a useful way with a subject only too frequently made an opportunity for platitudes. The tests on what we prefer to call the load factor of machine tools were taken with normal speeds and feeds, and in no case were the operatives' usual methods interfered with by the observer.

Tests were made on drilling, milling and planing machines, boring mills, lathes, grinding machines, presses and coil-winding machines, and the paper contained comprehensive tables under each head. It is not possible in the space at our disposal to reproduce the whole of the tables dealing with the tests and included in the paper, but we give that relating to drilling machines which is fairly characteristic of all.

Mr. Bailey said the figures disclosed will no doubt be criticised on the ground that the actual cutting time percentages are too low and not representative of average conditions. Great care, however, was taken to ensure that the tests were taken under ordinary conditions, and it is only due to the fact that those responsible for the information were broad minded enough to disclose figures some of which are obviously inefficient, that this section of the paper is possible. These figures, therefore, are of very great importance. It is certain that, if tests were made under the same conditions, similar figures would be obtained in most engineering shops, and considerably lower values would be disclosed if obtained by an impartial observer. There is a feeling, however, that to disclose such conditions would bring trouble to those directly responsible; it is therefore, necessary for any management, desirous of obtaining the real facts, and remedying the faults, boldly to accept full responsibility for the existing state of affairs, and then insist upon an immediate improvement.

It is essential that all time studies should be directed by an independent authority, that is, one who reports direct to the management. Every endeavour should be made to improve the methods employed with a view to obviating waiting and handling time, and increasing the actual cutting time to a maximum percentage of total time. Foremen should endeavour always to have the next job in evidence complete with drawings, jigs, tools, &c. Workpeople should be encouraged to make suggestions, and the extent to which they benefit thereby will influence the number of suggestions and their attitude to improved methods. Mention should be made of the fact that most of the work upon which the charts are based was of a miscellaneous nature, being general engineering work, and not repetition work, except in the few cases where it is so stated.

It is always a matter of discussion as to how far it is necessary to replace old types of drilling machines by machines of greater cutting capacity, and it is not generally realised that additional plant is seldom required, unless the handling time has been cut down to the absolute minimum. The table shows that unless special attention is paid to ease of controls of machines, extra setting tables, &c., very little gain can be made by using machines of say double the cutting capacity of existing machines; if, for instance, double cutting capacity were obtained and other conditions remained unchanged, the gain in output would only be, on the basis of this table: Radial drills*—average efficiency 27·9 per cent., gain 14 per cent.; pillar drills—average efficiency 35·4 per cent., gain 17·7 per cent., and if all the machines given on this chart were to be replaced to obtain this result, a very large outlay would be required for new machines.

An examination of other items on the chart will enable us to draw some interesting and valuable conclusions.

Item J—Job Setting.—It will be seen from the chart that the job setting time is a large proportion of the total time—on radial arm drills* an average of 22 per cent., and on pillar drills 22 per cent. also. It obviously does not need extra drilling capacity to deal with this part of the job, as by means of extra setting tables the drill can be kept at work whilst setting is proceeding on another table. The provision of extra setting tables also eliminates the waiting time—waiting for crane lifts, information, tools, &c., as this preparation work can be done on the extra setting tables; this is illustrated by the remarkable percentage figures of

* Observation No. D11—Multiple setting is excluded from these figures.

observation number D 11, the only observation taken on multiple setting work.

Item S—Setting for Cut.—The design of the machine has a great influence on these items and there is evidence that this has been tackled by drilling machine makers. A table was given showing a comparison of a centralised control machine and a non-centralised control machine on the same job showing for the former a saving of 39 per cent. of the time taken on the latter.

Another point of some importance is that drilling machines should always be equipped by the makers with a reliable quick-change drill chuck. This is a detail of great importance as it will bring about a gradual change-over to more efficient methods as machines are replaced.

Type.	Number of Observation.	Machine.	Character of Work.	Duration of Observation.	PERCENTAGE OF TOTAL TIME.										
						ANALYSIS OF REMAINING TIME.									
				h.m.	C. Cutting.	J. Job Setting.	T. Tool Setting.	S. Setting for Cut.	G. Gauging.	P. Personal.	M. Miscellaneous.	W. Waiting.	B. Breakdown.
Radial Drills	D 1	5-ft. Asquith radial	Drilling, tapping, &c., ball race and steam chest	15–20	31·9	7·4	12·0	7·6	2·3	4·7	16·0	16·3	1·8
	D 2	8-ft. Pond radial	Drilling and tapping yokes, bearings, boxes, &c.	24–40	24·6	18·6	12·2	10·6	2·4	2·0	7·5	21·9	0·2
	D 3	8-ft. Pond radial	Drilling and tapping fly-wheel	17–0	23·9	7·9	4·6	20·0	2·0	17·5	17·2	6·9	0·0
	D 4	8-ft. Pond radial	Drilling, &c., nozzle box and pinion frame	17–0	33·1	11·3	7·4	10·6	3·7	3·3	7·4	23·2	0·0
	D 5	8-ft. Hetherington	Drilling Lugs of half diaphragms	16–12	15·8	32·8	4·5	6·2	0·9	0·2	5·6	31·9	2·1
	D 6	53-in. Archdale radial	Drilling, &c., spiders, rings and shaft	21–18	22·7	20·6	11·9	7·6	4·7	2·0	18·2	10·9	1·4
	D 7	36-in. Archdale radial	Drilling levers, spindles, Flanges, &c.	8–28	15·6	24·2	6·1	3·0	4·5	8·1	21·6	16·9	0·0
	D 8	6-ft. Asquith radial	Drilling, spot facing, and tapping interpoles	12–0	28·9	16·7	7·0	21·7	2·0	4·7	7·8	11·2	0·0
	D 9	6-ft. Asquith radial	Repetition work, drilling and boring boxes in jig	5·0	38·0	29·4	20·1		3·1	2·3	2·7	4·4	0·0
	D 10	6-ft. Asquith radial	General work—one man	5–0	19·5	30·2	35·1		5·4	0·9	6·5	2·4	0·0
	D 11	6-ft. Asquith radial	General work—Multiple setting, two men	8–0	83·4	10·8	2·1		2·1	1·2	0·0	0·4	0·0
	D 12	Radial drill	Drilling cast steel magnet frame	6–3	16·4	30·6	11·7	8·8	5·0	7·8	12·0	7·7	0·0
	D 13	American drilling machine	Drilling rotor hub	10–5	50·0	14·0	15·0	6·5	6·5	2·0	2·5	2·0	1·5
	D 14	American drilling machine	Drilling end plate	62–0	43·0	42·0	9·5	1·4	1·1	1·5	0·5	1·0	0·0
Pillar Drills	D 15	26-in. Prentice	Drilling handwheels, flanges and half bearings	8–30	26·1	24·1	7·8	11·6	2·2	6·9	17·0	4·3	0·0
	D 16	34-in. Barnes	Drilling rings, valves, &c.	7–21	32·7	16·6	6·1	7·2	2·9	4·5	25·6	0·5	3·9
	D 17	Asquith patent	General work	4–30	31·0	16·8	17·8		3·6	0·0	25·4	3·5	1·9
	D 18	26-in. Prentice	Repetition work—drilling and countersinking interpoles	4–11	60·2	17·9	4·0	6·4	0·3	2·0	3·6	5·6	0·0
	D 19	26-in. Barnes	Repetition work—drilling and tapping bonding supports, &c.	8–20	26·8	34·6	21·2	8·0	1·8	2·9	4·1	0·6	0·0
Horizontal drill	D 20	Horizontal drill	Drilling cast steel magnet frame	10–30	31·6	10·7	10·8	22·2	1·3	0·6	14·9	4·7	3·2
Tapping Machine	D 21 D 22	Garvin Auto-Tapper	Tapping holes in interpoles	3–15	13·3	11·3	27·7	5·6	0·0	4·1	10·3	27·7	0·0

NOTES ON ABOVE ANALYSIS.

J. Includes filing, chipping or scribing as well as initial setting up and final dismantling. T. Includes obtaining speed and feed, grinding tool and fixing it in machine. S. Includes moving either tool or work (according to type of machine) into correct position for cut. G. Includes an examination, gauging and inspection, whether by operator or by inspector. M. Includes minor necessary operations such as receiving instructions; fetching and consulting drawings; fetching tools; making out time sheets; and oiling and cleaning. W. Includes all idle time not classified as personal delay, but not fetching tools, drawings, &c. B. Includes delays due to all troubles originating in machine or cutting tool.

Suppose we consider the three 8-ft. radial arm drills bracketed together, observation Nos. D3, D4, D5, which happen to form one group, and on the basis of the chart we compare the performances under the usual and under the proposed improved conditions, leaving the cutting time percentage for the present unaltered. One machine equipped with setting tables, centralised controls, quick-change chucks, will save 60 per cent. of the drilling time, 38 per cent. of this saving being due to setting facilities, and not to any improvement in the machine as shown below.

—	Old.	New.	—
	per cent.	per cent.	
C. Cutting time	24·3	24·3	Same.
J. Job setting	17·3	—	Done whilst cutting.
T. Tool setting	5·5	3·0	Done on centralised drill.
S. Set for cut	12·3	6·0	quick change chuck, &c,
G. Gauging	2·2	2·2	Same. " "
P. Personal	7·0	4·0	Approximately in proportion to time taken.
M. Miscellaneous	10·0	—	Done by setter.
W. Waiting	20·7	—	None, due to setting tables.
B. Breakdown	0·7	—	
	100·0	39·5	

In addition to the above 60 per cent. saving, if cutting time could be reduced by one-third (which would easily be possible, as the three machines in question are of a very old type), one drilling machine could replace the three machines quoted, and the proposal to install one up-to-date machine with a swing of 360 deg. in the middle of a floor plate would appear to be quite sound. There would be a great economy in floor space and a reduction in the total cost of the job, as the machine bears a higher overhead rate chargeable on the labour operating the machine, than is chargeable on the labour which is used for setting operations on the floor plate.

It would, of course, be necessary to provide assistance in setting up, obtaining cranes, drawings, tools, &c., and this assistance would have to be paid for, but there is no doubt that the greatest economy can be made by keeping the machine drilling the maximum possible percentage of the time. It is, perhaps, hardly correct to form definite conclusions from these three observations, lasting in all 50 hours, but from data gathered from other machines the results are thoroughly typical of drilling practice on general work.

REDUCTION GEARING.

TO THE EDITOR OF ENGINEERING.

SIR,—I read with much interest your treatment of this subject in your editorial in the issue of March 9. I trust you will permit me, however, to call attention to the fact that in our repeated blow test the test-piece is not rotated. A full description of this test will be found in your issue of December 15, 1922, pages 738 and 739.

Yours faithfully,
W. A. HATFIELD.

The Brown-Firth Research Laboratories, Princess-street, Sheffield, March 10, 1923.

"SUGGESTED SPECIFICATION FOR PERMANENT MAGNET STEELS."

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to the correspondence which has recently appeared in ENGINEERING in connection with my article under the above title, which was inserted in your Journal on February 2, I request permission to make several comments, and also to thank Mr. Robert Cochran Gray, of the University of Glasgow, for his very interesting letter giving an alternative treatment of the subject.

I agree with him that saturation intensity, I_s, the measure of the intrinsic magnetisation of a material is particularly applicable to permanent magnet steels. In my opinion, however, the testing of magneto-magnets in large quantities does not permit its inclusion in a specification in such cases, inasmuch as its value can only be obtained from Fröhlich's equation in the form $\frac{1}{\kappa} = \alpha + \beta H$, in which β is the reciprocal of I_s. In other respects Mr. Gray and I are in perfect agreement.

I am also pleased that my friend Mr. E. A. Watson accepts the proposal to introduce the grading of permanent magnet steels in order to secure the recognition of quality and reliability, and hence to secure a reasonable price for the finished product. We, however, appear to differ in one respect, namely, that a specification should only contain such values of the constants which refer to the design of magneto-magnets. For purposes of design the values of $(\beta\ \psi)_{max.}$ suffice; but additional information is required if one desires to investigate matters relating to the working and operative qualities of a magneto. Two important features of magneto-working occur to my mind, *i.e.*, the question of the *permanency* of a magnet, and the phenomenon of *magnetic elasticity*, an essential feature of magneto operation upon which Mr. Watson is an acknowledged authority.

Before submitting my specification it appeared to my mind that it was essentially necessary to include in a suggested specification such constants which have received recognition for many years, if only to give an opportunity to dispense with them.

It is well known that there is no single-valued constant of a magnet which characterises its suitability as the essential part of a magneto. The first two items in the specification are single-valued constants obtained by the ordinary tests, the remainder are either products or quotients of single-valued constants, and are therefore *derived* constants. I may add that I hold no brief for the introduction or acceptance of the product $B_r \times H_c$, used almost universally during the war period; nor can I recall to mind its origin or why it is associated with the term "magnetic strength." It is still used by some magneto manufacturers, and inasmuch as the minimum values of the components are also specified, one may, with a little experience and judgment, satisfy himself as to its usefulness and limitations.

With respect to the ratio $\frac{B_r}{B_{max.}}$ or $\frac{I_r}{I_{max.}} = c$, designated the coefficient of retentivity, it may be mentioned that this derived constant has been used for some twenty years as a critical measure for purposes of acceptance or rejection. It may not be known that in the Bosch magnetic tester which was used almost universally as a workshop instrument during this period, the scale consisted of a series of numbers expressing the minimum values of the coefficient of retentivity for different sizes of magneto-magnets, which were acceptable.

Then again, the rate of change in the slope of the descending curve of the hysteresis loop is one of the most critical measures of the nature and condition of the material, and obviously the value of c will be indicative of the nature of the slope of the curve from $I_{max.}$ to I_r.

Furthermore, standard tests on horseshoe magnets under closed-circuit conditions imply the use of a massive keeper of wrought iron, and it is interesting to ascertain ballistically or by means of a flux-meter, what change occurs in the magnitude of I_r when the keeper is detached, the magnetising force H being, of course, zero during this test. The new value of the remanent intensity, I_{r_1}, is known as the *open circuit remanence*, and the relationship, $\frac{I_{r_1}}{I_r}$, a type of coefficient of retentivity, is an indication of the nature of the slope of the demagnetising portion of the curve. These aspects of the problem receive support from evidence I have obtained that the ratio $\frac{I_{ss} - I_{r_1}}{I_{r_1}}$ is approximately the reciprocal of the corresponding value of H_c. In a similar manner it is suggested that $\frac{H_c}{I_r}$, the measure of the *specific reluctivity* at the remanence point, may give some indication of the probable *permanence* of the magnet; in any case its measure is readily obtained from the primary tests. Similarly, the product $H_c \times C$ includes a factor which is dependent upon the nature of the slope of the curve.

Yours faithfully,
ELLIS H. CRAPPER,
Electrical Engineering Laboratories, University of Sheffield.

KENYA COLONY.—The Director of Public Works, and H.M. Trade Commissioner Nairobi, is desirous of being supplied with priced catalogues of the building and engineering trades for the Department of Public Works. Catalogues should be addressed to the Director of Public Works, Public Works Department. Head Office: Nairobi. Or to H.M. Trade Commissioner (P.O. Box 220), Bonia Building, Government-road, Nairobi.

THE EMPLOYMENT OF EX-OFFICERS.—We have been requested to announce the fact that the Appointments Department of the Ministry of Labour is anxious to obtain the assistance of consulting engineers and others in advising on the qualifications of ex-officer applicants for engineering vacancies and also with regard to the opportunities for employing such ex-officers. The work would entail voluntary attendance at the Engineering Panels, 3 and 4, Clement's Inn, Strand, W.C. 2, for 2 hours either weekly or fortnightly. The advice which engineers could give the department and the unemployed ex-officers themselves would be greatly appreciated by both, and those of our readers who may be able to offer their services in the capacity indicated are invited to communicate with the officer-in-charge at the address mentioned above.

HYDRAULIC SHEARING MACHINE AND WHEEL PRESS.

THE illustrations on this page show two examples of modern practice in the design and construction of hydraulic machinery. In this type of plant sturdiness is an essential characteristic and was, in fact, the foundation of the excellent reputation which British manufacturers have built up in this field. The examples illustrated are machines with essentially differing purposes, the one for shearing and the other, a horizontal wheel press. Both were built by Messrs. Fielding and Platt, Limited, of Gloucester.

A hydraulic plate shear with a blade 14 ft. 6 in. long and capable of cutting plates up to 1¼ in. thickness is shown in Fig. 1. The frame work of the machine consists of heavy steel castings for the front girder, the vertical side frames, and a box-girder which serves as the back guide to the shear slide. The front girder carries the lower shear blade. Gaps in the two side frames, 3 ft. 6 in. deep, make it possible to split, down the middle, any length of plate, 7 ft. wide. The top girder is extended upwards to form bearings for the fulcrum pivots on which the operating levers work, and also supports on the back the three main hydraulic cylinders. The shear slide is made of cast-iron in the form of a box-section and works between planed surfaces on the side frames and back connecting guides. This machine is of the triple-powered type and can be operated at one-third, two-thirds or full power, according to the requirements of the work upon which the machine is employed. The three main cylinders have their rams connected to the shear slide by a strong treble-armed steel lever. Each arm is connected to one of the rams and to the shear slide by means of thrust rods of cast iron, the lower ends of which are formed with spherical bearing surfaces and fit into corresponding machined cups. The upper ends of these thrust rods are connected to the operating levers by hardened steel pins working in bronze bushes. Hydraulic plate-gripping cylinders and rams are provided at the front of the machine. The lifting of the shear blade is effected by a pair of hydraulic cylinders fixed upon the top of the main frame. Constant pressure is exerted in these lifting cylinders, the rams work upwards and have their crossheads connected to the shear slide by tie rods. The water for operating the machine is controlled by a special arrangement of valves of the balanced mitre-seated type, which enable the force exerted in the machine to be controlled through cams by a single lever.

An example of a modern hydraulic wheel press is illustrated in Fig. 2. This machine is capable of exerting a total pressure of 400 tons and is of a size sufficient to deal with wheels up to 6 ft. diameter, and with axles up to 8 ft. 6 in. long. A forged steel pillar-type crane is part of the equipment and is of 4 tons capacity, with a maximum radius of 7 ft. 6 in.

The main cylinder is part of a crosshead casting which is made of Siemens cast steel and forms one side of the frame of the machine. Two horizontal tie rods made of forged steel and provided with machined cotter holes at intervals, extend between the fixed crosshead and a simple upright. To facilitate the handling of work to and from the machine, by means of the jib crane and by the overhead crane in the workshop, the top tie is not directly above the bottom one, but set back. The movable crosshead is made of cast steel, is mounted upon rollers and is held in position by the usual machined cotters.

The supply for the machine is obtained by the operation of self-contained hydraulic pumps driven from a motor through machine-cut gearing. The motor and gearing are situated on the back of the main crosshead, and drive a shaft passing through to the front, where two eccentrics give motion to the pump plungers. In the illustration the supply tank is shown beside the machine. Both strokes are made quick-acting by the use of the available hydraulic pressure. In forward acting the supply operates behind the ram, while for the return movement an annular area between the two diameters of the ram receives the pressure. The complete machine is supported on a cast-iron bedplate, which may be securely bolted to the foundation.

THE PLACING OF CONTRACTS ABROAD.—A deputation representing numerous trade associations of Great Britain and the Dominions, was received on Friday, February 23, by Sir William Joynson-Hicks, Secretary to the Department of Overseas Trade. The object of the deputation, which was led by Mr. Ben H. Morgan, Chairman of the British Empire Producers' Organisation, was to support the proposal that it should be obligatory on every Government Department and on every railway and public authority in the United Kingdom, to purchase goods entirely of British Empire origin, and to employ only British labour on contracts and work. Sir William Joynson-Hicks stated, in his reply, that the Board of Trade was in full sympathy with the objects in view, and that the representations which had been made by the deputation would be given full consideration.

SHEARING MACHINE AND WHEEL PRESS.

CONSTRUCTED BY MESSRS. FIELDING AND PLATT, LIMITED, ENGINEERS, GLOUCESTER.

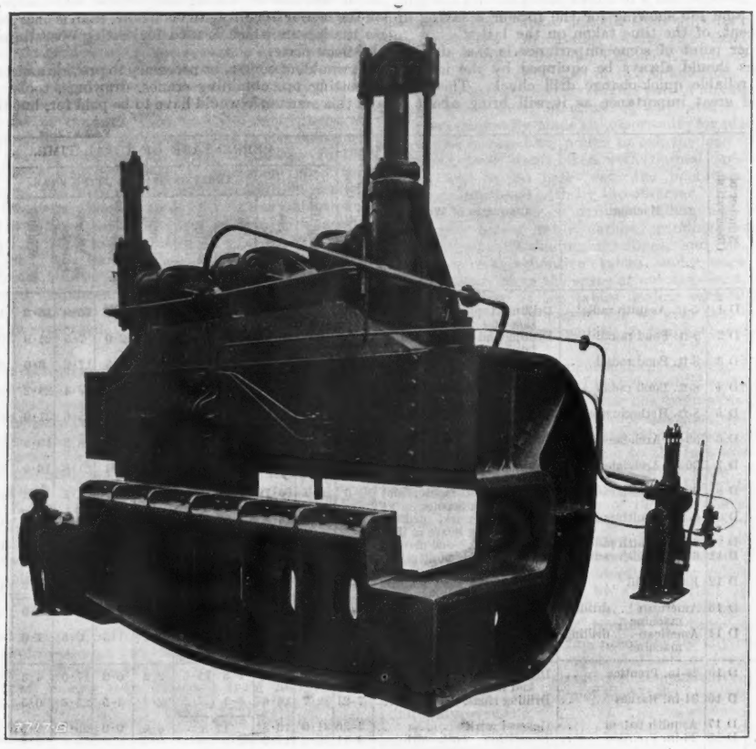


FIG. 1. HYDRAULIC SHEARING MACHINE.

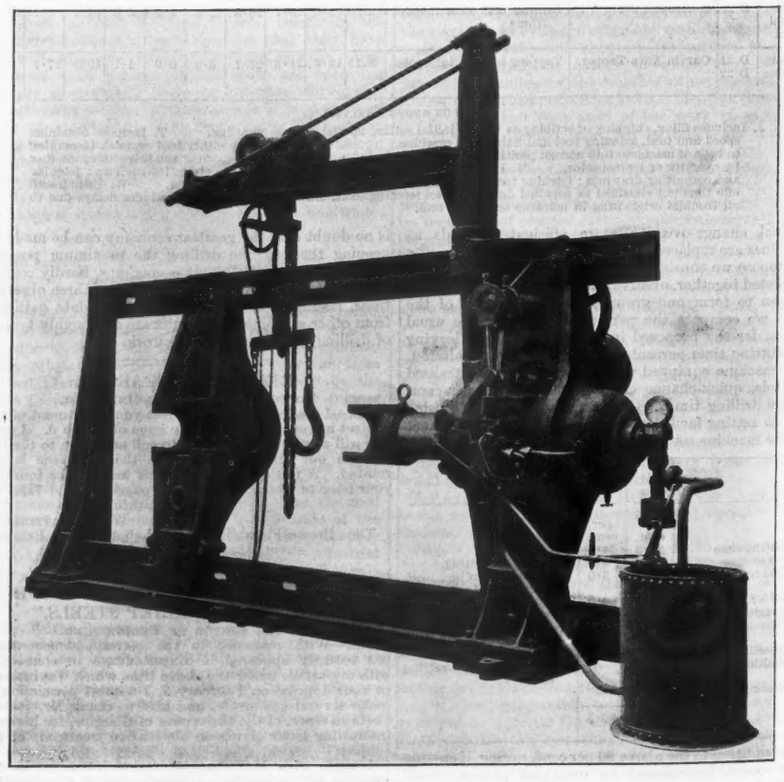
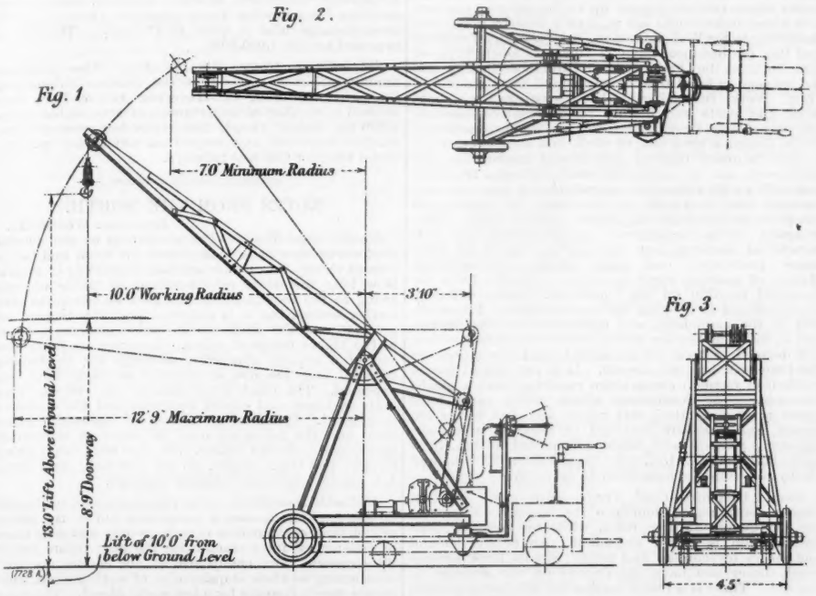
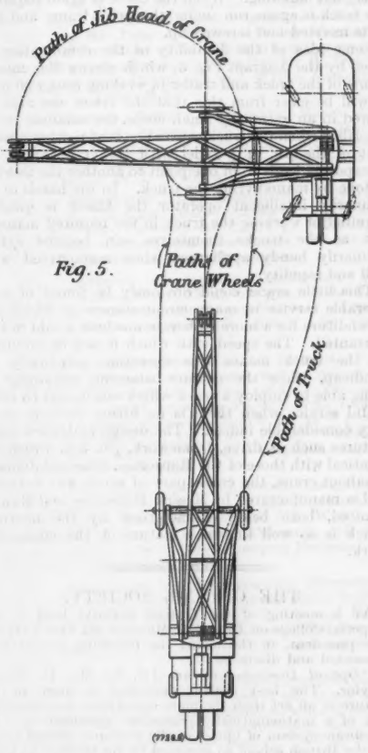


FIG. 2. 400-TON HYDRAULIC WHEEL PRESS.

15-CWT. TRAILER CRANE.

CONSTRUCTED BY MESSRS. RANSOMES AND RAPIER, LIMITED, ENGINEERS, IPSWICH.





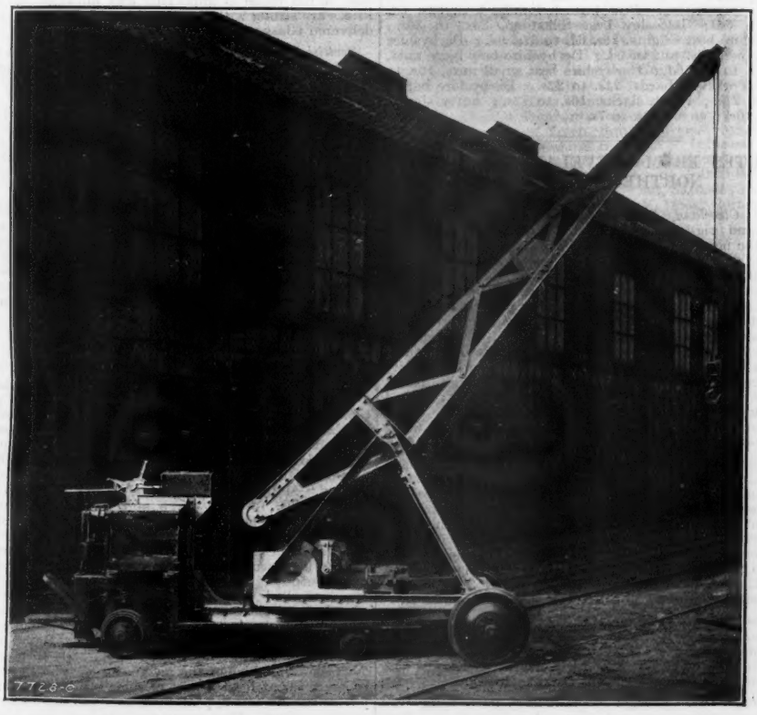


FIG. 4.

A VERY handy and serviceable little appliance in the way of a portable crane is illustrated in Figs. 1 to 5, on this page. This crane, constructed by Messrs. Ransomes and Rapier, Limited, of Ipswich, is arranged to be used as a trailer in connection with the type of battery truck now commonly used in workshops, warehouses, &c. The crane itself has only two rubber-tyred wheels, a third support being provided by a pivot temporarily carried on the deck of the truck, which serves not only as the connection for moving the crane from point to point wherever the work may require it, but also by relying upon the weight of the truck, secures additional stability when under load. In our Figs. 1 to 3 the full lines indicate the crane itself, and the dotted lines the truck to which it is attached. The truck shown is one of Messrs. Ransomes, Sims and Jefferies' "Orwell" Electric Industrial trucks, but is only typical, as the crane can be fitted to any of the usual types available, whether with two large and two small wheels, or four large wheels. Steering may be either by two or four wheels, but by preference for handiness in confined spaces four-wheeled steering should be provided if possible.

The actual size illustrated is a 15-cwt. crane working to a 12-ft. radius. The weight of the crane is 1 ton 15 cwt., when the hook is light about 18 cwt. of this being carried by the truck. When the crane is loaded there is a slight upward pull on the truck. The crane body or frame is built up of small channels and angles, and is triangular in shape. The lattice jib is pivoted at the apex of the frame. Derricking motion is arranged for the jib, the rope for this being carried over pulleys on a tail or back extension of the jib, and down to a drum in the bottom of the frame. Hoisting is by a two-part tackle, both ends of the rope being carried over pulleys at both ends of the jib, one part being wound in on the drum, the other being made fast to the frame. Both motions are derived from one electric motor of 3 h.p. run at 1,500 r.p.m. off the batteries of the truck. The motor drive is by worm with two clutches, one for each motion. As the clutch engages, a brake is progressively released, to be applied again in the same manner as the clutch is thrown out, when the movement is accomplished.

The crane has a maximum radius of 12 ft. 9 in. and a minimum radius of 7 ft. At 10 ft. radius the height to which the hook can be raised is 13 ft., while rope and drum accommodation are provided to enable a lift to be made from 10 ft. below ground level. The jib can be lowered to the horizontal so that the crane can be taken through an 8-ft. 9-in. doorway. The width between wheel centres is 4 ft. 5 in.

The crane shown in the photograph reproduced in Fig. 4 differs slightly from the later model depicted in the drawings, with regard to the pivot arrangements. In the former design (Fig. 4) a pivot was provided capable of being fixed to the truck platform by four bolts. It was fitted with a universal joint. The new design embodies a rather more substantial ball and socket connection, the cup being mounted on a frame which has two guiding shoes which help to centre the crane quickly on the truck platform. Two holding-down bolts are then inserted and tightened up. These attachments, together with the plug connection to the battery on the truck for supplying power to the crane motor, complete the unit, and the crane is then ready for work. The ball and socket allow for differences of level of the surface traversed. To this pivot frame is attached an angle-iron extension to the top of the battery box of the truck, where the control is fitted. There is only one control lever, by which, however, five movements are possible. These are hoisting, lowering the load on brake without power, lowering the hook or very light loads by means of the motor, luffing the jib in, or luffing it out on the brake. The control lever is arranged close to the truck controls and can be operated by the man in charge while standing on the footboard.

The trailer unit is fixed to the truck by bolts passing through the pivot frame and the truck deck. To

disconnect the crane or to mount it on the truck is only a matter of a few seconds. The crane is conveniently left anchored down by the lifting tackle being secured to some fixture or heavy weight, and if the strain is just taken and the brake applied the bolts can be undone, the truck run away for other use and the crane safely left standing. When the crane is again required the truck is again run under the pivot frame and the bolts inserted and screwed up.

Some idea of the flexibility of the combination is given by the diagram Fig. 5, which shows the movements of the truck and trailer in working round 90 deg. It will be clear from this that the crane can also be slewed in an extremely small circle, the smallest being described when the truck centre line is at right angles to that of the jib, or parallel with the crane axle. In transposing loads from one point to another the slewing is done by manœuvring the truck. In the hands of an ordinarily intelligent operator the knack is quickly acquired of working the truck in the required manner, just as the trucks themselves can become extraordinarily handy appliances when manœuvred with skill and rapidity.

This little crane could obviously be found of considerable service in many circumstances in which the expenditure for a more elaborate machine would not be warranted. The speed with which it can be mounted on the truck makes this operation practically no handicap, while the counter-balancing advantage of being able to employ a truck which can be put to other useful service when there is no lifting work to do is very considerable indeed. The design embodies many features such as drive, framework, jib, &c., which are identical with those of the Ransomes, Sims and Jefferies runabout crane, the crane part of which was designed and is manufactured by Messrs. Ransomes and Rapier, Limited, both being characterised by the neatness which is so well known a feature of the company's work.

THE OPTICAL SOCIETY.

AT a meeting of the Optical Society, held at the Imperial College on Thursday, March 8, Sir Frank Dyson, vice-president, in the chair, the following papers were presented and discussed:—

"*Optical Designing as an Art*, by Mr. H. Dennis Taylor. The best optical designing is more of the nature of an art than the mere calculation and carrying-out of a mathematically prescribed specification. The algebraic system of optics of the first and second orders of the British school as initiated by Sir George Airy and Henry Coddington, and also the undeveloped third order of the same together constitute the source of creative inspiration by which all advances in optical constructions and inventions are rendered possible, while the practice of what is known as ray tracing, so largely employed in Germany, should only be regarded as of quite secondary importance, so much so, in fact, that its employment is quite unnecessary, provided that the algebraic system and all its implications be sufficiently grasped and digested. Several illustrations were given of optical combinations, including the Cooke photographic lenses, a simple anastigmatic periscope and an anastigmatic flat field microscope, which have been worked out without any resort having been made to ray tracing operations, the author's system of algebraic formulæ having always been found to give quite sufficient guidance.

"*The Distribution of Corrective Duties in Optical Instruments*," by Mr. T. Smith, M.A., F.Inst.P. The conditions which should be satisfied by the components of a complex system are determined in a convenient form in terms of the aberrational conditions which the complete instrument has to satisfy. The use of the method evolved is illustrated by a lens of three elements such as the "Cooke" photographic lens.

WOMEN'S ENGINEERING SOCIETY.—A conference of this society is to be held at Birmingham University Edgbaston, from April 11 to 14, particulars concerning which can be obtained from Miss C. Haslett, 26, George-street, Hanover-square, London, W. 1.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—At the last meeting of this Institution, which was held at the Engineers' Club, Coventry-street, W.C., on Friday, the 9th inst., Lieutenant-Colonel J. T. C. Moore-Brabazon delivered his presidential address. This took the form of a lantern lecture on the subject of aerial photography, in which the president traced the development of the photographic section of the Air Force during the course of the war. He dealt with the types of cameras and methods of mounting employed, mentioning in connection with the latter that rubber sponge had been found to give the best results in absorbing vibrations. He also referred to the difficulties at first experienced in obtaining supplies of dense barium-crown glass for lenses, and added that its subsequent production in this country must be regarded as a great technical triumph. Colonel Moore-Brabazon stated that without aerial photography, trench warfare would have resulted in a complete deadlock, but that with its aid it had been possible to make arrangements for an attack with a good general idea of the difficulties to be encountered. That the utility of the information obtainable was fully appreciated in the later part of the war is shown by the fact that at the end of 1918 the photographic section was producing finished prints at the rate of about 2,000,000 a month.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The improvement in the steel and engineering trades is much more pronounced in some sections than others. A tour of the industrial area of South Yorkshire reveals a considerable number of large works whose output is quite up to the pre-war average, and whose order books are in a very healthy condition. According to Sir Walter Preston, Messrs. Henry Bessemer and Co., for instance, have 3½ times as much work on their books as they had a year ago, and more than double the tonnage in hand than at any period since the end of 1920. Works furnishing steel and castings for rolling-stock and parts and fittings for locomotive renewals are particularly busy. The call for textile machinery is still finding a good deal of work, and there is certainly a more buoyant tone in agricultural implements and machinery, and in automobile steel. Forges, foundries and rolling mills reflect the general state of improvement. Crucible steel continues to constitute an unfortunate exception to the otherwise almost general uplift. Consumption is on the increase in engineering and constructional sections, but war stocks offered at rates below production cost seem almost inexhaustible. Makers of common steels continue to benefit from the unsettled position on the Continent. Great difficulty is experienced in meeting full requirements. Prices are still in the ascendant, and consumers in this district and in the Midlands are taking heavy deliveries, but are not inclined to book too far ahead until the outlook on the Continent becomes clearer. It is anticipated that a re-birth of German competition resulting from a pacific arrangement of Continental affairs would cause local prices to slump. Both soft billets and acid billets are dearer, and rises are recorded in common and basic pig-iron. Siemens acid billets are quoted at 12*l.*, hard basic billets at 9*l.* 15*s.*, soft basic billets 9*l.* 10*s.*, and Derbyshire common irons from 5*l.* 5*s.* to 6*l.*

South Yorkshire Coal Trade.—Movement in best steams continues to dominate the market. Exporters are big buyers at firm rates, while on home account consumption is in the ascendant. An active demand has set in for cobbles and nuts. Smalls have become much firmer and have appreciated on the average 1*s.* per ton. There is a ready market for all classes of coke, accompanied by a disconcerting shortage of furnace sorts. Quotations:—Best branch handpicked, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 25*s.* 6*d.* to 27*s.* 6*d.*; Derbyshire best house, 23*s.* to 24*s.* 6*d.*; Derbyshire best large nuts, 20*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best small nuts, 16*s.* to 19*s.*; Yorkshire hards, 21*s.* to 22*s.*; Derbyshire hards, 20*s.* to 21*s.*; rough slacks, 10*s.* to 12*s.*; nutty slacks, 8*s.* to 10*s.*; smalls, 3*s.* to 7*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is hardly any Cleveland pig-iron to be had. Makers are fully sold over the next two months, and second hands have little iron to offer, so that as there is general disinclination to negotiate ahead on anything like an extensive scale, business is still confined to very narrow limits. Some home consumers complain of the high prices named, but exporters are not hesitating to pay the ruling rates for any odd parcels that come on the market. Another idle furnace or two may shortly be in operation, but there seems little or no likelihood of output being sufficiently enlarged to meet needs for some time to come. No. 1 is put at 130*s.*; No. 3 has sold at 127*s.* 6*d.*; No. 4 foundry is 125*s.*; and No. 4 forge, 120*s.* These prices are f.o.t. makers' works, f.o.b. Tees quotations being half-a-crown above the foregoing figures.

Hematite.—Recent substantial sales of hematite have placed producers in a very strong position, many firms having in fact disposed of their output for the second quarter of the year. In this branch, however, merchants are not so badly off for supplies as is the case with regard to Cleveland pig-iron, and they are selling at prices that are cheap in comparison with values of Cleveland sorts. Mixed Nos. of East Coast hematite have steadily advanced to 122*s.* 6*d.* both for home purposes and for despatch to customers abroad, and No. 1 is at a premium of 1*s.*

Blast-Furnace Coke.—Durham furnace coke keeps scarce, but notwithstanding the abnormally high prices obtainable for export, sellers are still offering medium qualities at 40*s.* delivered to regular local consumers, who are prepared to renew contracts on such terms.

Foreign Ore.—Foreign ore is lifeless, users being well off for supplies, and not disposed to negotiate. Best rubio is 25*s.* c.i.f. Tees.

Manufactured Iron and Steel.—There is continued heavy all-round demand for manufactured iron and steel, but trading is undoubtedly quieter. Producers, however, are well placed, several firms indeed having more contracts secured than they can well deal with. Quotations are very strong, railway material, billets, and sheets being particularly stiff. Principal market rates:—Iron rivets, 14*l.*; soft billets, 10*l.*; hard billets, 10*l.* 5*s.*; steel boiler plates, 14*l.*; steel ship, bridge and tank plates, 10*l.*; steel angles, 9*l.* 10*s.*; heavy steel rails, 10*l.* 10*s.*; fish plates, 14*l.* 10*s.*; black sheets, 15*l.*; and galvanised corrugated sheets, 19*l.* 10*s.*

Another Shipyard for Teeside.—The great Tyneside firm of Messrs. Swan, Hunter and Wigham Richardson, shipbuilders, and marine engineers, have acquired a large tract of land on the south side of the Tees near Georgetown, for the establishment of a shipbuilding yard. It is stated that the Tees Conservancy Commissioners have undertaken to carry out any improvements in the River Tees which will facilitate the enterprise. The land purchased for the project was previously owned by Messrs. Bolckow, Vaughan and Co., Limited, to whose steel works it is in close proximity.

Important Shipbuilding Order for the Tyne.—Messrs. Armstrong, Whitworth and Co., Limited, have secured an order from Sweden for a passenger vessel of 17,000 gross tonnage with a speed of 17 knots. The boat is expected to cost 1,000,000*l.*

Shipbuilding Orders for the Tees.—The gratifying announcement is made that the Furness Shipbuilding Company, Limited, of Haverton Hill-on-Tees, have secured a number of important contracts including one 8,000-ton motor vessel, two 4,000-ton steamers, two smaller steamers, and important orders for constructional steel for Colonial railways.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The conditions at the Scottish steel works show little change over the week and for the present at any rate a fair amount of activity is general. How long this state may continue is rather doubtful owing to the reluctance on the part of buyers to place further orders, but it is expected that the demand will get better as the weeks go on and consumers get used to the higher range of prices. Inquiries are fairly good and of a general character, although for shipbuilding material they are not so plentiful as might have been expected. The black sheet makers are well employed, both on home and export business, and the outlook is very good. Prices of all classes of material continue firm, and the following may be taken as the current quotations:—Boiler plates, 13*l.* per ton; ship plates, 9*l.* 15*s.* per ton; angles, 9*l.* 5*s.* per ton; and sheets, 12*l.* per ton, delivered Glasgow stations.

Malleable Iron Trade.—The recent advance in the price of bar iron has caused a temporary lull in the placing of new business, but that is perhaps only a passing phase, as consumers' requirements for the near future are not all covered. The conditions at the works are fairly satisfactory as there is quite a lot of work booked, which means steady running for a few weeks ahead. The export side of the trade is improving and inquiries are good. Prices are strong with "crown" bars called 12*l.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—In the Scottish pig-iron trade the demand continues to be quite equal to the present-day output and everything on offer is going quickly into consumption. Foundry iron is the subject of good business, despite the firmness in prices, which are 6*l.* 3*s.* 6*d.* per ton for No. 1 quality, and 5*l.* 18*s.* 6*d.* per ton for No. 3 quality, both on trucks at makers' yards. There is quite a steady demand for hematite from the local steel makers, and the current quotation is 6*l.* per ton, delivered at the steel works.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour keep well ahead of last year's figures, thus showing the improvement in trade. The total shipped for the week ending last Saturday, November 9, was 4,207 tons, all of which, except 65 tons, went foreign. For the corresponding week last year the figures were 683 tons foreign and 196 tons coastwise.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Available supplies of coal of practically all grades are so scarce that buyers experience difficulty in securing even small quantities. The general demand remains active and prices continue to improve. All the large coals are firm on the basis of 35*s.* for best Admiralty and Monmouthshires and smalls are up to 27*s.* 6*d.* Many salesmen decline to quote, though some indicate 40*s.* for best large and 30*s.* for best smalls. Operators are, however, unable to reap to the full the benefit of the urgent demand because as a result of shipping congestion at the docks the collieries are not able to keep working regularly and produce their maximum outputs. In numerous cases collieries fully sold are compelled to effect temporary stoppages, because of a lack of clearance of loaded wagons or a shortage of empty trucks due to wagons under load being held up at the docks awaiting shipment. The demand is not confined to prompt delivery, but extends to shipment over the remainder of the year. Buyers show eagerness to cover for at least a part of their future requirements, but sellers do not appear in a hurry to close except at current values. Best steam and dry large has, however, been sold for delivery over the year at 30*s.* and smalls at 23*s.* 6*d.* Though there is a deadlock in respect to the introduction of a third working shift by the trimmers and tippers at the docks a move has been made to accelerate trimming work as the Joint Control Board for Cardiff, Penarth and Barry, have put on an extra 90 trimmers, and intend further increasing the number by about 100. This should help to minimise delays, for quicker trimming will result in a speeding up of shipment operations. That speeding up is necessary will be gathered from the fact that to-day there were 60 vessels waiting for loading berths at Cardiff, Penarth, Barry and Newport. 25 at Swansea and 17 at Port Talbot. In February, 2,275,794 tons of coal were shipped abroad, of a value of 2,762,125*l.* compared with 2,398,248 tons valued at 2,803,274*l.* in January. This decrease in the volume of trade was chiefly due to the fact that the 24 working days in February were three less than in January. However, there is little doubt that had the shipment facilities been able to cope with the demand, the volume of trade

in February would have exceeded that of January despite the shorter working period. Large steam coals exported in February averaged 26*s.* 10*d.* per ton, or 5*d.* more than in January, and steam smalls 17*s.* 11*d.*, an increase of 11*d.* Anthracite coals were also higher in price, the February average for large at 36*s.* showing an increase of 3*d.* and of small at 20*s.* 1*d.* of 1*s.* 7*d.* per ton.

Colliery Deal.—Shareholders in the Imperial Navigation Coal Company, Limited, have received an offer from North's Navigation Collieries (1889), Limited, to acquire the whole of the ordinary capital of the Imperial Company on the basis of four 5*s.* North's fully-paid ordinary shares for every 1*l.* fully-paid share in the Imperial Company. The directors of the Imperial Company have agreed to accept the offer, and decided to recommend acceptance to the shareholders. The scheme will link the Imperial Navigation, Celtic and North's collieries under a single proprietary control, and as the three properties adjoin each other will give North's control over that part of the South Wales coalfield extending from Port Talbot to Bridgend.

Personal.—Mr. Charles Edward Cleeves, J.P., head of the firm of Cleeves and Co., and the Western Valleys Anthracite Collieries, Limited, Swansea, has been elected chairman of the South Wales Coalowners' Association for the ensuing year.

THE INSTITUTION OF MINING AND METALLURGY.—The following awards have been made by the council: (*a*) The gold medal of the Institution has been awarded to Mr. Edgar Taylor, president, 1909–11 and 1916–18, honorary treasurer since 1913, in recognition of his services to the Institution since its foundation in 1892 and as evidence of an appreciation of his honourable record of work in connection with the development of the mining industry, particularly in India. (*b*) "The Consolidated Gold Fields of South Africa, Limited," gold medal has been awarded to Dr. Leonard Hill, F.R.S., in recognition of his valuable researches on ventilation, and for his paper on "Ventilation and Human Efficiency," contributed to the transactions. (*c*) "The Consolidated Gold Fields of South Africa, Limited," premium of 40 guineas has been awarded to Mr. Henry Francis Collins, Assoc.R.S.M., for his paper on "The Igneous Rocks of the Province of Huelva and the Genesis of the Pyritic Ore Bodies," contributed to the Transactions, and in recognition of his researches on the subject.

CONTRACTS.—Messrs. Yarrow and Co., Limited, Glasgow, state that they have secured a contract for a number of large water-tube boilers forming part of the boiler equipment for the New Barking Power Station of the County of London Electric Supply Company, Limited.—The Folkestone Corporation have just accepted the tender of Messrs. D. J. Somerville and Co., Limited, for 31,450*l.*, and the Staveley Coal and Iron Company for 13,034*l.* 10*s.*, for the construction of a new sea outfall from the harbour along the beach close to the East Cliff and Copt Point. For the sewer, 48 in. diameter cast-iron pipes are to be used, specially coated to withstand the action of sea water. The beach is subject to storms, and great precautions have to be taken to hold the pipes in place. At the lower end a chamber is to be constructed with agitating weirs to break up any solids remaining in the sewage, and also to act as an air buffer against the ramming action of the incoming waves. The engineers are W. H. Radford and Son, Nottingham. Work is to be started as soon as possible.

THE LATE PROFESSOR VAN DER WAALS.—Few modern scientific names are so familiar to the physicist, chemist and engineer as that of Professor Johannes Diderik van der Waals, who died at Amsterdam on March 8. The expression "equation of state" is pre-eminently linked with the name of Van der Waals; the "state" refers to the equilibrium conditions of the molecules of a liquid and its gas. According to the "gas law" of Boyle and Charles the volume v of a gas varies with the pressure p and the absolute temperature T in such a way that $p\,v = R\,T$, where R is the gas constant. But no gas strictly obeys this law. Van der Waals expressed, in 1873, the relation in the form $\left(p + \frac{a}{v^2}\right)(v - b) = R\,T$, where a and b are constants depending upon the particular gas, a being connected with its cohesive force (in other words, the attraction between the molecules, which is strong when the substance is in the liquid state and still present in the gaseous state) and b representing the volume actually occupied by the gas molecules themselves. Van der Waals gave his equation of state in his doctorial thesis, presented to the University of Leiden in 1873, on the "Continuity of the Liquid and Gaseous State." The work of Andrews (1869), James Thomson (1871), and others, on critical states and on continuity of states had preceded him; other equations of state have since been given, and some of them have been used by preference under certain conditions, because none hold universally. Van der Waals did other signal work in thermodynamics and on the kinetic theory, on capillarity, phases, specific volumes and cognate problems, also concerning solids, and he received many honours in recognition of his researches. The Nobel prize for Physics was awarded to him in 1910. He was born in Leiden in November, 1837, and was thus in his 86th year at his death. His whole life was spent in Holland, and most of his papers were published by the Amsterdam Academy and in the Harlem Archives; an English translation of his dissertation appeared in 1890. When the University of Amsterdam was established in 1877, he was appointed to the chair of physics, which he occupied with distinction.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, March 16, at 6 p.m., at Storey's Gate, S.W. 1. General Meeting. Second Report of the Steam Nozzles Research Committee.

THE INSTITUTE OF METALS: SWANSEA LOCAL SECTION.—Friday, March 16, at 7.15 p.m., at the University College, Singleton Park. Paper on "Gaseous Firing of Industrial Furnaces," by Mr. E. W. Smith, D.Sc.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, March 16, at 7.30 p.m., at 39, Victoria-street, S.W. 1. "Comparative Power Costs," by Mr. C. H. Woodfield. Friday, March 23, at 7.30 p.m. Lecturette, "The History and Development of the Underground Railway," by Mr. R. J. Siddall (Member).

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, March 16, at 7.30 p.m., in the Lecture Theatre, Literary and Philosohpical Society, Newcastle-upon-Tyne. "Notes on the Economical Performance of Turbine Installations in Merchant Ships," by Mr. T. S. Potts.

THE NORTHAMPTON ENGINEERING COLLEGE, ENGINEERING SOCIETY.—Monday, March 19, at 5.30 p.m., at St. John-street, E.C. 1. Paper on "Reconstruction Work at Beckton Gas Works," by Mr. W. B. Leech.

THE NEWCOMEN SOCIETY.—Tuesday, March 20, at 5.30 p.m., at Prince Henry's Room, 17, Fleet-street, E.C. 1. Paper on "The Early History of the Gas Process," by Mr. David Brownlie, B.Sc., F.I.C.

BRADFORD ENGINEERING SOCIETY.—Monday, March 19, at 7.30 p.m. Lecture in the Hall of the Bradford Technical College. Mr. J. M. Walshe, A.M.I.E.E. (of Birmingham), on "High-Speed Air Compressors," illustrated by lantern slides.

THE INSTITUTION OF ELECTRICAL ENGINEERS: NORTH MIDLAND CENTRE.—Tuesday, March 20, at 7 p.m., at the Hotel Metropole, King-street, Leeds. Report of the British Electrical Research Association on "Permissible Loading of British Standard Paper-Insulated Electric Cables," presented by Messrs. S. W. Melsom and E. Fawssett.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, March 20, at 6 p.m. Papers to be submitted for discussion: "The Improvement of the Water-Supply to the City of Hobart, Tasmania; and the Manufacture of Reinforced-Concrete Pipes by the Centrifugal Process," by Mr. John Clark Ross, M.Inst.C.E.; "The Mazoe Irrigation Dam," by Mr. Mark Randall, Assoc.M.Inst.C.E.; "The Works for the Augmentation of the Supply of Water to the City of Cape Town, South Africa," by Mr. David Ernest Lloyd-Davies, M.Inst.C.E. Informal Meeting, Wednesday, March 21, at 7 p.m. Subject for discussion: "Electric Train Lighting," to be introduced by Mr. J. R. W. Grainge. Students' Visit, Saturday (afternoon), March 24, to the King George V. Dock, Port of London Authority.

THE INSTITUTE OF MARINE ENGINEERS.—Tuesday, March 20, at 6.30 p.m., at 85 to 88, The Minories, Tower Hill, E. 1. "Operation of Marine Oil Engines, Cylinders and Pistons," by Mr. John Lamb.

SOCIETY OF GLASS TECHNOLOGY.—Wednesday, March 21, at 2.45 p.m., in the Latin Theatre, The University, Edmund-street, Birmingham, the following papers will be read and discussed: (*a*) "A Rapid Method of Testing the Durability of Glassware," by Mr. H. S. Blackmore, Miss Violet Dimbleby, B.Sc., and Professor W. E. S. Turner, D.Sc.; (*b*) "The Corrosion of Fireclay Refractory Material by Glass and Glass-making Materials," by Mr. Donald Turner, B.Sc. Tech. (lately Salter's Research Fellow) and Professor W. E. S. Turner, D.Sc.; (*c*) "The Effect of Saltcake in Corroding Fireclay Materials," by Edith M. Firth, B.Sc., Mr. F. W. Hodkin, B.Sc., and Professor W. E. S. Turner, D.Sc.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—NORTH OF ENGLAND CENTRE.—Wednesday, March 21, at 7.30 p.m., at the Y.M.C.A., Albion-place, Leeds. "Principles of Vehicle Suspension," by Mr. H. S. Rowell.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, March 21, at 8 p.m., at the Royal Institution, Colquitt-street, Liverpool. Paper by Professor G. E. Scholes, on "Combustion of Fuel."

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, March 21, at 7.30 p.m., at 49, Cromwell-road, South Kensington, when a Lecture on "The Characteristics of the Atmosphere up to 200 km., as obtained from observations of meteors," will be delivered by Mr. G. M. B. Dobson, M.A. The chair will be taken by Dr. C. Chree, F.R.S., President.

THE INSTITUTION OF NAVAL ARCHITECTS.—Wednesday, March 21, to Friday, March 23. Annual Meeting at the Royal United Service Institution, Whitehall, S.W. 1. Wednesday, March 21, at 11 a.m.:—Papers to be read and discussed: "A Proposed Aircraft-Carrying Mail Steamer," by Sir Eustace T. d'Eyncourt, K.C.B., D.Sc., F.R.S., and Mr. J. H. Narbeth, C.B., C.B.E., M.V.O., R.C.N.C.; "Coastal Motor Boats in War-time," by Sir John E. Thornycroft, K.B.E., and Lieutenant Bremner, R.N. Wednesday afternoon, at 3 p.m.: "Remarks on Some of the Present-Day Problems in the Design of Ships," by Mr. A. C. F. Henderson. Wednesday evening, at 7.30 p.m.: Annual dinner in the Grand Hall, Connaught Rooms, Great Queen-street, W.C. 2. Thursday, March 22, at 11 a.m.: "Mechanical Gearing," by The Hon. Sir Charles A. Parsons, K.C.B., D.Sc., F.R.S., Mr. S. Cook and Mr. H. M. Duncan; "Electric Ship Propulsion," by Mr. W. Le Roy Emmet. Thursday afternoon, at 3 p.m.: "Model Screw Propeller Experiments with Mercantile Ship Forms," by Mr. G. S. Baker, O.B.E., and Mr. W. C. S. Wigley. Thursday evening, at 8 p.m.: "The Powering of Motor Ships," by Mr. K. C. Barnaby, B.Sc. Friday, March 23, at 11 a.m.: "The Behaviour of Stiffened Thin Plating under Water Pressure," by Professor T. B. Abell, O.B.E., M.Eng. "Further Experiments on Large-Size Riveted Joints," by Mr. J. Montgomerie; "The Influence of Form upon the Stability and Propulsion of Passenger Ships," by Mr. John Anderson. Friday afternoon, at 3 p.m.: "The Effect of Variations in Loading on Longitudinal Structural Stresses in Ships," by Mr. W. Thomson; "Graphical Trim Calculation and a Trim Nomogram," by Mr. E. V. Telfer, M.Sc.

THE OPTICAL SOCIETY.—Thursday, March 22, at 7.30 p.m., at the Imperial College, Imperial Institute-road, South Kensington, a lecture on "Surveying and Nautical Instruments from a Historical Standpoint" will be delivered by Dr. L. C. Martin.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON).—Thursday, March 22, at 7 p.m., at the Engineers' Club, Coventry-street, W. 1. "The Theory and Practice of Steam Jet Instruments," by Mr. J. N. Gresham, Associate Member, Manchester.

THE INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—Friday, March 23, at 7.30 p.m., in the Mappin Hall of the University, St. George's-square. Paper on "Further Notes on Britannia Metal," by Captain F. Orme, M.Met.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, March 23, at 9 p.m., a discourse will be delivered by Sir Ernest Rutherford, LL.D., D.Sc., F.R.S. The subject is "Life History of an Alpha Particle from Radium." Afternoon Lecture, Saturday, March 24, at 3 p.m., Sir Ernest Rutherford, LL.D., D.Sc., F.R.S. Professor of Natural Philosophy, on "Atomic Projectiles and their Properties" (Lecture VI).

THE INSTITUTION OF PRODUCTION ENGINEERS.—Friday, March 23, at 7.30 p.m., at the Engineers' Club, Coventry-street, London, when Mr. Axel Wickman, of Messrs. Alfred Herbert, Limited, Coventry, will deliver a paper dealing with "Modern Gauging Systems" to be illustrated by lantern slides.

THE INSTITUTION OF ENGINEERING INSPECTION.—Friday, March 23, at 7.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2. Annual Meeting. Paper by Mr. Kyrle W. Willans, on "The Future of Steam as Applied to Motor Vehicles and Agricultural Engines."

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, March 27, at 8 p.m., at the House of the Royal Society of Arts, John-street, Adelphi, London, when a paper on "Window Design and the Measurement and Predetermination of Daylight Illumination," will be read by Mr. P. J. Waldram, F.S.I., and Mr. J. M. Waldram, B.Sc.

INSTITUTE OF TRANSPORT.—The fourth dinner of the Institute will take place at the Savoy Hotel, London, on the evening of Thursday, May 3. The Institute will hold its third annual Congress at Sheffield on Thursday, Friday and Saturday, June 14 to 16. Papers will be read and discussed, and there will be visits to places and works of transport interest. Full details will shortly be available.

BRITISH IRON AND STEEL PRODUCTION.—The National Federation of Iron and Steel Manufacturers state that the production of pig-iron in February amounted to 543,400 tons, or 24,500 tons less than in January, mainly owing to the smaller number of days, for the average daily rate of production was about 6 per cent. higher than in January. The furnaces in blast at the end of the month numbered 189, an increase of six during the month. The production included 174,000 tons of hematite, 184,800 tons of basic, 125,900 tons of foundry and 30,300 tons of forge pig-iron. The output of steel ingots and castings in February amounted to 707,100 tons, which is the highest output attained since December, 1920, and is higher than the rate of production in 1913.

THE LATE MR. JAMES THOMAS JERVIS.—After a lifetime devoted to the development of railways and electric tramway traction, Mr. James Thomas Jervis, died on Tuesday, March 13, at 27, Brompton-square, at the age of 78. He served articles with Mr. P. J. Margary, chief engineer of the South Devon Railway, after which he worked successively on the construction of the Dartmouth and Torbay Railway, the Indus Valley Railway, and the London and North-Western Railway in South Wales. During the years 1869 and 1871 he acted as chief engineer of survey and construction, on a section of the East Hungarian Railways and carried out extensive surveys for proposed extensions through the passes in the Carpathian Mountains into Roumania and Moldavia. Later he went to Buenos Aires to take charge of the railway surveys across the Pampas to Chile, and executed the work preliminary to the extension of the Uruguay Railways. Since 1873 he had been in practice as a civil engineer in Westminster, and in association with his partner, Mr. Wilkinson, he built the Midland and Great Northern Joint Railway in Norfolk and the line from Luleo in Sweden to the Ofoten Fiords in Norway, which was the first railway to pass within the Arctic Circle. Mr. Jervis was one of the founders of the Notting Hill Electric Lighting Company, and was a director of that and many other electric lighting and tramway companies. He was elected a member of the Institution of Civil Engineers in 1893 and was also a Fellow of the Royal Geographical Society.

REINFORCED CONCRETE PIER AT SHELLHAVEN.

CONSTRUCTED TO THE DESIGNS OF MESSRS. EDMOND COIGNET, LTD., ENGINEERS, LONDON.

(*For Description, see Page* 319.)

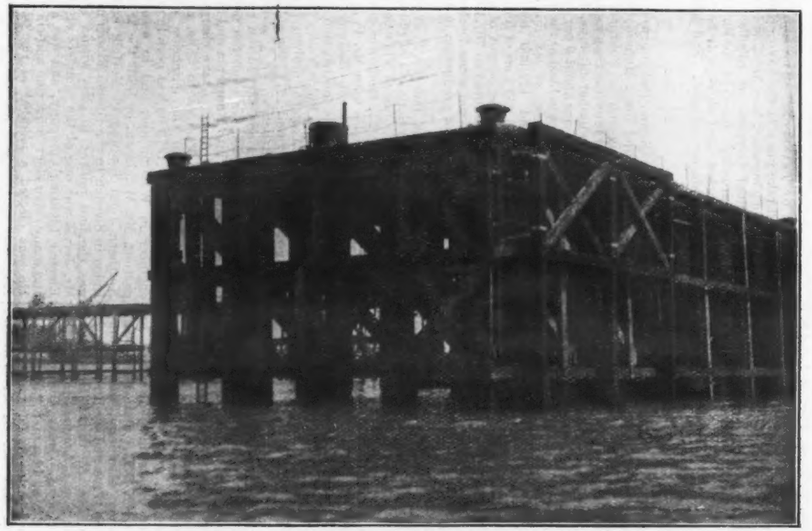


FIG. 33. END OF PIER HEAD SHOWING SPRING FENDERING.

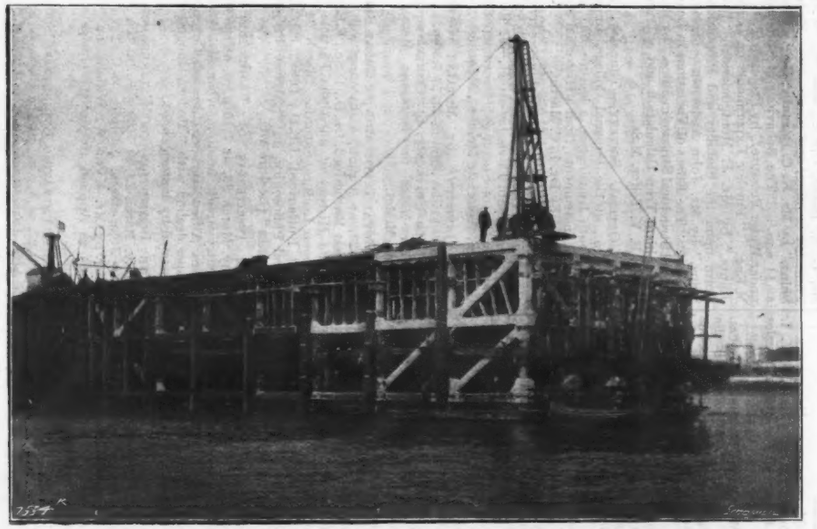


FIG. 34. PIER HEAD SHOWING HORIZONTAL AND DIAGONAL BRACING.

FIG. 35. THE SHORE JETTY.

FIG. 36. VIEW UNDERNEATH SHORE END OF JETTY.

Fig. 35. The Shore Jetty.

Fig. 36. View underneath Shore End of Jetty.

REINFORCED CONCRETE PIER

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Fig. 4. LONGITUDINAL SECTION 6.6.

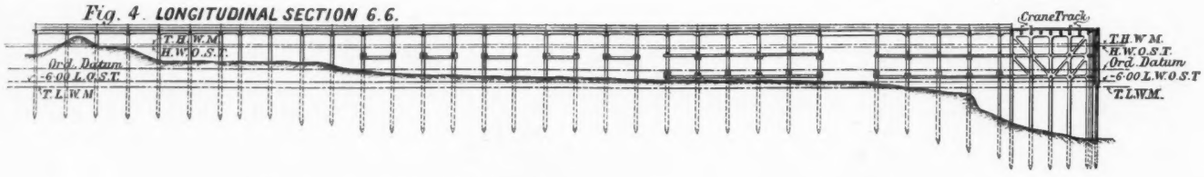


Fig. 5. ELEVATION OF TEE HEAD.

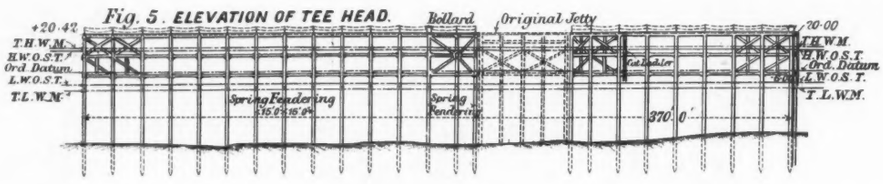


Fig. 6. SECTION 1.1.

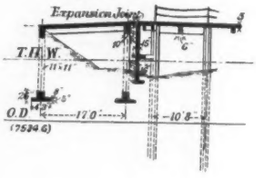


Fig. 7. SECTION 2.2.

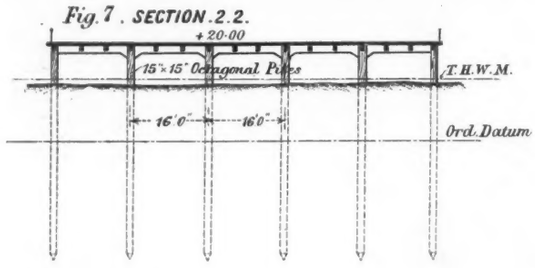


Fig. 8. DECK PLAN (LOOKING UP).

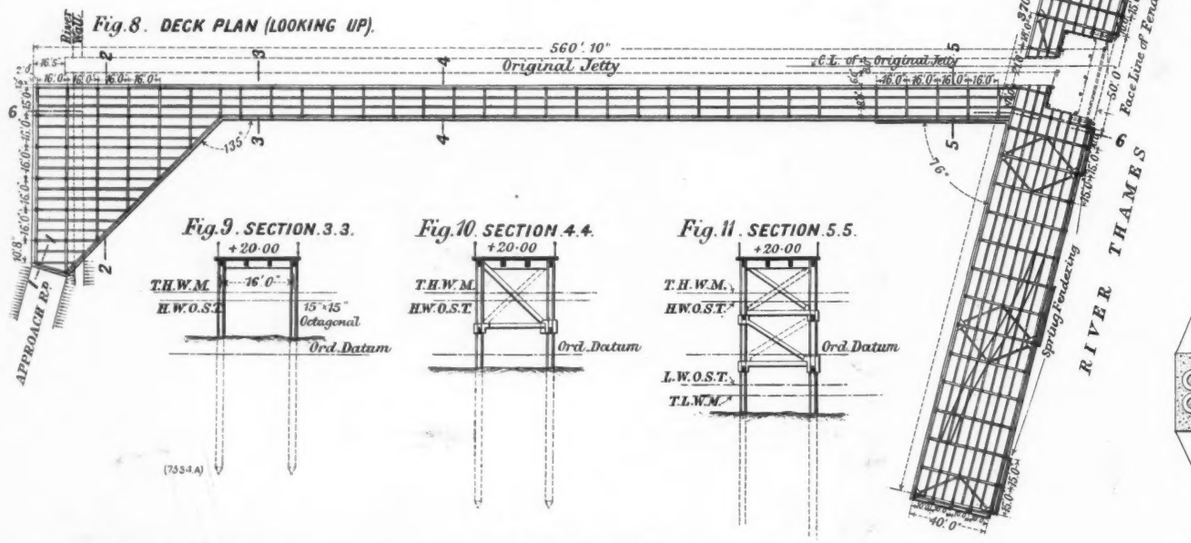


Fig. 9. SECTION 3.3.

Fig. 10. SECTION 4.4.

Fig. 11. SECTION 5.5.

Fig. 12. TRANSVERSE BRACING TO TRESTLES Nos 30-32 INCLUSIVE.

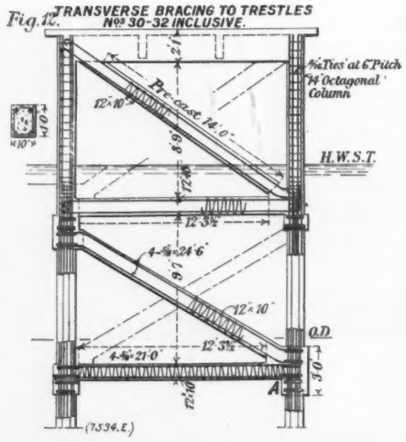


Fig. 13. HORIZONTAL BRACING TO TRESTLES Nos 22-32 INCLUSIVE.

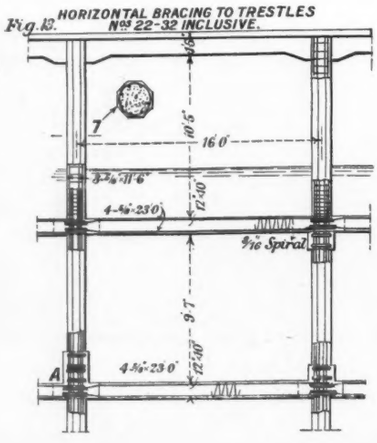


Fig. 14. TRANSVERSE BRACING TO TRESTLES Nos 12-21 INCLUSIVE.

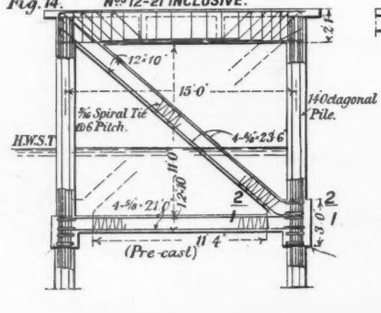


Fig. 15. HORIZONTAL BRACING TO TRESTLES Nos 12-21 INCLUSIVE.

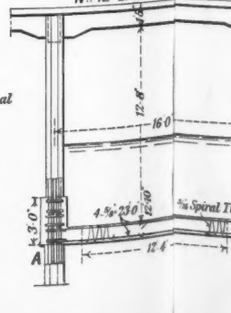


Fig. 17. Detail at 10-10

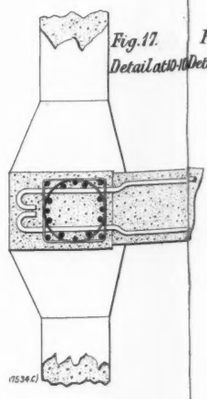
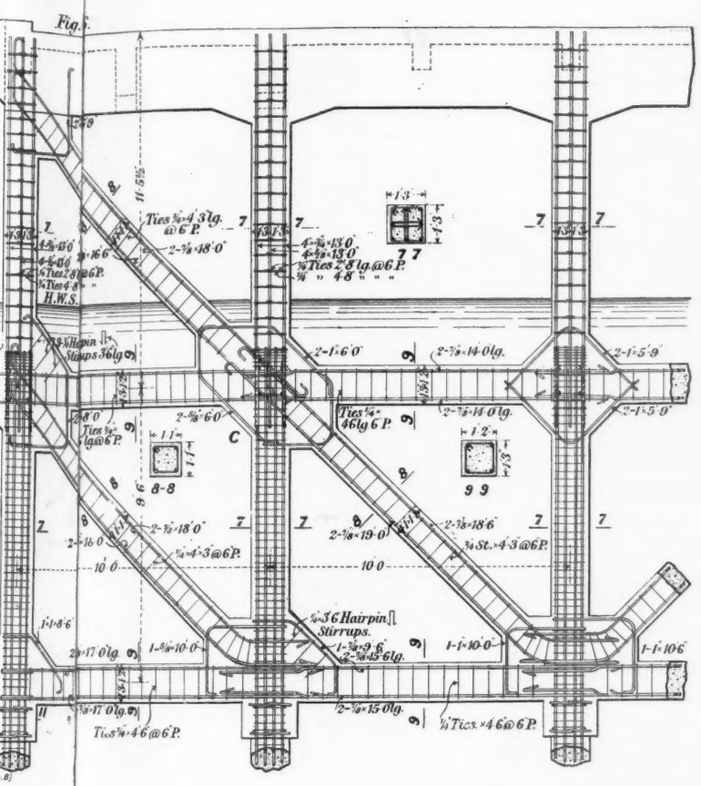


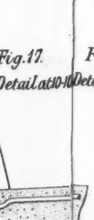
Fig. 16. Detail at

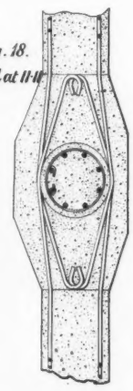
RETE PIER AT SHELLHAVEN.

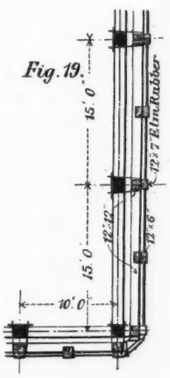
ESSRS. E D COIGNET, LIMITED, ENGINEERS, LONDON.

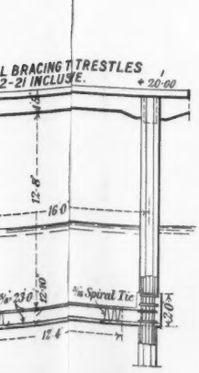
Description, Page 319.)

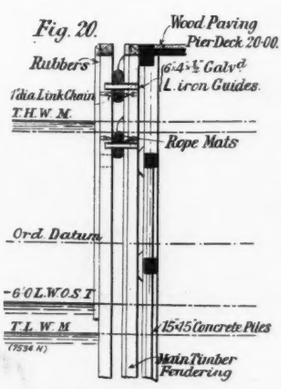


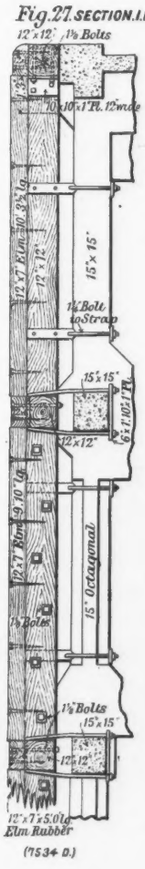


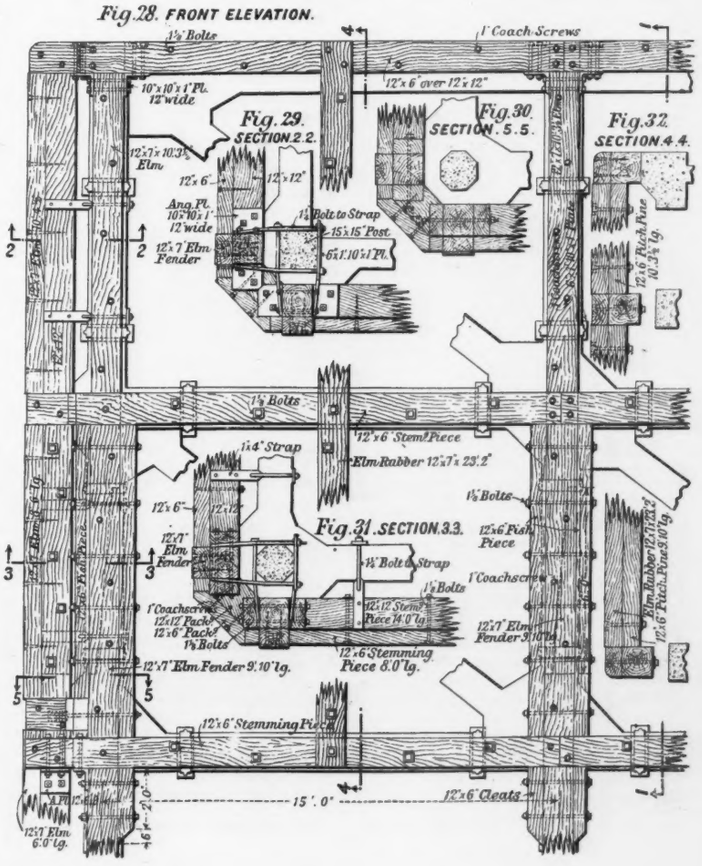


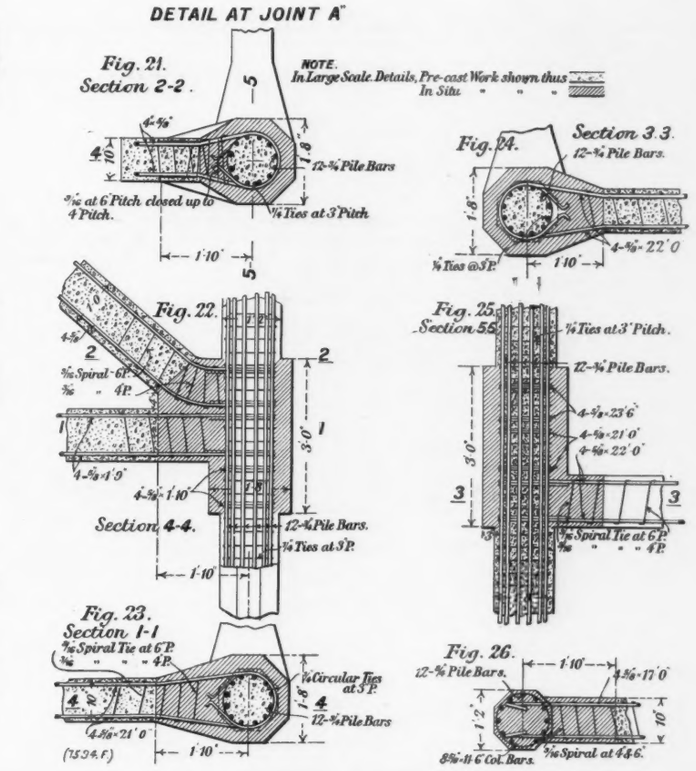












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Two-Page Plate.—REINFORCED CONCRETE PIER AT SHELLHAVEN.

ENGINEERING.

FRIDAY, MARCH 16, 1923.

THE NAVY ESTIMATES.

THOSE who regard the British Navy as an insurance policy on the peace of the world will hear with pleasure the statement made in the House on Monday last by the First Lord when introducing the Navy Estimates, to the effect that the irreducible minimum of naval strength, as far as this country is concerned, has now been reached. The extent of the reductions so far effected is sufficient to give rise to anxiety in some quarters and could only be justified in view of exceptional financial conditions and on account of the anticipated effects of the Washington Treaty in reducing competitive naval construction. In this connection it must be borne in mind that although the Treaty has not yet been ratified by the other signatory Powers, Great Britain has already scrapped 17 of the 18 capital ships which were to be disposed of in accordance with its terms, leaving only the Lion to be dealt with subsequently. In thus giving effect to our obligations under the Treaty in advance of the other Powers, this country has performed what the First Lord described as an "act of faith" which it is hoped will lead the other nations concerned to ratify the Treaty at an early date and completely to carry out its terms.

This action leaves us with 22 completed capital ships, which are still regarded by our naval advisers as the essential factor in naval warfare, and two new battleships just laid down. About four years will be required for the construction of these ships, and when they are completed, four others are due to be scrapped, leaving us with a total of 20 capital ships. The United States, on the other hand, has 18 capital ships completed, two of which will shortly be replaced by new ships of the "West Virginia" class. These vessels will give the United States Navy three ships of post-Jutland design, while until the two new capital ships are completed we have no vessel in which the lessons of the war have been fully incorporated. Our most modern capital ship, the Hood, it will be remembered, although modified as a result of the Jutland action, was commenced before that battle, and its construction had proceeded too far to permit of all the modifications in design that might otherwise have been made; Japan, it should be mentioned, has two post-Jutland ships. In light cruisers and aircraft carriers Great Britain is stronger than the United States, but the latter country is distinctly superior with regard to destroyers and submarines.

Remembering that, possessing as we do a widely-scattered Empire and that the naval responsibilities of this country are far greater than those of any other nation, the present position cannot be regarded with complete equanimity. We have, however, accepted the risk and have been able to secure some much-needed relief for the Exchequer, but this has, of course, been done on the assumption that the Washington Treaty will be effectively ratified by all the signatory Powers. If this is not carried out, the situation would certainly need to be most carefully reconsidered.

The net estimates for 1923–24 amount to 58,000,000*l.*, a figure which the First Lord pointed out would probably have been some 20,000,000*l.* higher, but for the effect of the Treaty. It is actually 6,883,700*l.* lower than the estimate for the current year and 25,444,000*l.*, or 30 per cent., less than the corresponding figure for 1921–22. The total of the effective votes for the coming year amounts to 50,102,100*l.*, as compared with 54,719,400*l.* for 1922–23 and 76,553,300*l.* for 1921–22, the respective figures for the non-effective votes being 7,897,900*l.*, 10,164,300*l.* and 6,890,700*l.* The high value of the figure, for 1922–23, is accounted for by the fact that about 3,000,000*l.* was absorbed by the special immediate provision necessitated by the reduction of *personnel*, but the subsequent additions to the retired pay and pension lists are indicated by the fact that the total non-effective votes for 1923–24 exceed those for 1921–22 by over 1,000,000*l.*; this unavoidable expenditure must, of course, be continued for some years. It is expected that the total reduction of the *personnel* of the Fleet by 20,000 officers and men which was to have been made during the current year, will have been completed by April 1, except that 140 officers and 1,000 men have been retained until a decision has been made by the Government with regard to the Admiralty's proposal to provide the *personnel* for the naval air service. The Imperial Defence Committee, it is understood, is considering and will report on the divergent views of the Admiralty and the Air Ministry as to the control of the air force for the Navy.

The actual estimated number of officers, seamen, marines, coast guards and marine police for the coming year is 100,923, as compared with 121,400 for the current year and with 142,960 for the year 1913–14. As a result of the reduction in numbers, and also owing to a further fall in the cost of living, the first three votes in the new estimates relating to pay, victualling and clothing, and the medical services, are together less by 2,763,800*l.*, than those for the current year, the three items being 14,055,700*l.*, 4,742,500*l.* and 516,000*l.*, respectively. The cost of civilians employed on Fleet services has also been reduced from 292,100*l.* in the current year's estimates to 194,900*l.* in those for the ensuing year. The reduction in the estimates for the educational services from 411,000*l.* to 353,000*l.* is due mainly to the termination of the short course at Cambridge University arranged for officers who had suffered loss of training owing to the war. The new scheme for training engineer officers came into force in May last and will include instruction in electrical engineering as well as in marine engineering. The complete course will occupy four years, the whole period being spent at the Royal Naval Engineering College at Keyham, except for four months' study at the Portsmouth Torpedo School. The vote for the scientific services is utilised mainly in connection with research and experimental work, and is therefore one in which real economy is likely to be achieved more by judicious expenditure than by parsimony. The total estimated expenditure under this heading is, however, somewhat less than that for the current year, the actual figures being 435,800*l.* for 1923–24, as compared with 446,500*l.* for 1922–23, but the difference appears to be mainly due to reductions in the cost of the work and of the maintenance of the research establishments rather than to a curtailment of these essential

activities. The cost of the naval reserves for the ensuing year is estimated at 572,800*l.*

The vote for shipbuilding work, repairs, maintenance, &c., it will be remembered, is divided into three sections, of which the first two relate to dockyard work, while the third has reference to contract work. The first section includes the salaries and wages paid to dockyard officials and workmen, whose numbers have been greatly reduced as was indicated in the estimates for the current year. No further reductions in numbers are likely to be made, and additional men have, in fact, been temporarily engaged during the winter in order to relieve unemployment. The expenditure contemplated in this section is 6,694,000*l.*, which is nearly 1,000,000*l.* less than the estimate of 7,680,100*l.* for the year now concluding. An even greater reduction has been effected in the second section of this vote, which covers dockyard *matériel*. In this direction, the estimated expenditure is 5,988,200*l.* as compared with 7,263,700*l.* for the current year, the difference of 1,275,500*l.* being accounted for by a reduction of 930,500*l.* in the cost of stores and of 345,000*l.* in the allowance for the fuelling of the Fleet. As was the case in the previous estimates, this item has been cut down to an extent which can only be justified by the exceptional financial stringency. Obviously the building up of adequate reserves of oil fuel both at home and abroad is a matter of the utmost importance, but this has been retarded for financial reasons.

The remaining section of the shipbuilding vote relates to contract work and is naturally augmented by the expenditure on the two new battleships Nelson and Rodney, now under construction. The provision in this section for the new ships amounts to 2,914,160*l.*, as compared with only 300,000*l.*, allowed in the previous estimates, but the difference of 2,614,160*l.* is set off, to some extent, by reductions in other directions. The total figure under this heading for the coming year is 5,031,450*l.*, as compared with 3,334,500*l.* for the current year, the actual increase thus amounting to 1,696,950*l.* Expenditure on the new battleships is also included in the vote for naval armaments, a sum of 670,000*l.* being earmarked for this purpose. But for this, the armaments vote would have been materially reduced owing to decreased costs, and also because the cost of research work on chemical warfare, formerly included with armaments, has now been transferred to the vote for the scientific services. The net result is, however, an increase of 280,400*l.*, the total cost of armaments for the forthcoming year, being estimated at 5,344,900*l.*, as compared with 5,064,500*l.* for the current year. If a number of less important items distributed among other votes be included, it is expected that the total expenditure on the new battleships for the whole year will exceed 4,000,000*l.*

The vote for expenses in connection with works buildings and repairs at home and abroad, which it will be remembered was greatly reduced in last year's estimates, has been still further reduced in the estimates just presented. The reduction arises from the fact that some of the larger works have been completed and of the new works proposed, only those which are essential to the safety of structures and ships, to the efficiency of the Fleet, or to the well being of the *personnel* are being carried out. The new works are mainly for the provision of storage accommodation for oil fuel, but the most interesting item is one of 160,000*l.* to be voted for preliminary work in connection with the construction of a new naval base at Singapore, where oil fuel storage accommodation is already in hand. The total cost of the new base will amount to 11,000,000*l.*, and the necessity for it arises from the fact that the modern battleship has outgrown existing docking facilities in the East. The terms of the Washington Treaty preclude the possibility of making extensions at Hong Kong, and since the dockyard at Wei-Hai-Wei has been closed down and negotiations are proceeding for the return of Wei-Hai-Wei itself to China, the need for developing a new naval centre in the Far East will be generally admitted. The total sum to be voted for works amounts to 3,832,850*l.*, as compared with 4,273,000*l.* in last years' estimates.

The only other effective votes are those of 1,059,600*l.* for travelling and miscellaneous expenses and of 1,280,400*l.* for the upkeep of the Admiralty Office, both of which show a reduction, the former of 852,300*l.*, and the latter of 140,400*l.*, in comparison with the estimates for the current year. These, with the non-effective votes of 7,897,900*l.*, bring the total estimates to the figure of 58,000,000*l.* previously mentioned. This figure it may be pointed out is only 19 per cent. greater than the actual expenditure for the pre-war year of 1913–14, which was 48,732,621*l.*, but of this sum less than 3,000,000*l.* was accounted for by non-effective items. It is only by comparing modern costs and wages with those of pre-war times that the recent reductions in naval expenditure can be fully appreciated.

PETROLEUM FIRE RISKS.

In addressing the Institution of Petroleum Technologists at the annual meeting held on Tuesday last, Professor J. S. S. Brame, retiring after two years' presidency, was able to give a very gratifying summary of the widened activities of the Institution. The number of members has risen from 387 to 569 since 1920, the status of the Institution is officially and privately recognised in all questions affecting the petroleum industry, thousands of inquiries reach the office every month, and the circulation of the Journal, edited by Dr. Dunstan, has much been enlarged. Though engineering problems have certainly not been neglected, Mr. H. Barringer M.Inst.C.E., whom Professor Brame introduced as his successor, is the first engineer to preside over the Petroleum Technologists.

As subject for his presidential address Professor Brame had selected the question of fire risks. The statistics of our country prove that proper rules and due caution can successfully check the dangers which volatile oils constantly threaten. Professor Brame pointed out in this connection that even the explosive industry is not more destructive to life and property than any other, because the danger is understood and care is taken. But appalling accidents shake that confidence from time to time, and England is not a petroleum-producing country. The American statistics of the Bureau of Mines, to which Professor Brame particularly referred, and on which we have commented on various occasions, look terrifying, and lightning is the most dreaded source of danger, though there is no proof that lightning prefers oil tanks to homesteads. In the three months May to July, 1915, 198 tanks and one pipe line station were destroyed by fire in Oklahoma, and 179 of these fires were attributed to lightning. That America, the country of the greatest automobile development, leads also in minor-scale accidents, caused by petrol or gazolin, need hardly be pointed out. In 1913 already 1,040 people were killed and 3,121 injured by gazolin, and of every 1,000 cases of fire, 771 were ascribed to gazolin, and 99 of these to static electricity.

In vapour ignition volatility and explosive range are chief determining factors. In coal-tar benzene the lower and upper limits of inflammability, 1·4 per cent. and 4·7 per cent. of benzene in air mixtures, correspond to temperatures of — 5 deg. and + 5 deg. C. Though limited the temperature ranges are larger in toluene and pentane, the volatility of petrol is such that, in closed vessels, the upper limit of inflammability is quickly exceeded. That is no safeguard, however, against accidents arising from vapour escapes, and the peculiarities of vapour-inflammability have often been commented upon by us in connection with papers brought before the Institution of Petroleum Technologists and other bodies. Professor Brame stated that, whilst flames and a fairly high temperature were, of course, dangerous, a glowing coal, a burning cigarette, and sparks from iron would very rarely ignite petrol. But electric sparks would generally explode petrol, and the hammering with a chisel of a tank cap had killed many people. The greatest danger lurked in the frictional electricity generated by petrol in motion. There, again, were odd features; Richter had observed explosions at — 15 deg. C., under conditions when no explosion took place at + 15 deg. C.; this, we think, is explained by the fact that the upper limit of explosibility had been exceeded in the richer vapour at the higher temperature. Professor Brame also mentioned a peculiar case of a coal-gas explosion that had occurred in a steel tank serving as lethal chamber for cats. Three baskets of cats had been lowered into the tank through a trap in the glass lid; in the fourth basket was a cat which struggled, and sparks were probably emitted by the fur. Similar accidents had happened to chauffeurs wearing fur coats. To avoid risks in filling car tanks, both the tank and the filler should be earthed, and they should be interconnected by a chain, and rubber hose pipes should not be used.

The vapour danger in oil tanks could be reduced by ventilation and by providing the exits with gauze windows and caps as in the safety lamps. Since iron and also copper were liable to corrosion, Professor Brame proposed to try nickel gauze. Wooden covers were objectionable because burning wood might fall into the oil. To prevent lightning and to extinguish fires, steam had been discharged into the top of tanks; a spray of steam at 200 lb. per square inch had successfully been used in Germany as a blanketting agent. During the past year "sealite" had come up in America. This was a mixture of glucose, glycerin, glue, starch, calcium chloride and water, beaten up with air—carbon dioxide would be better; that mixture floated on the top of the oil, but it would not readily adapt itself to level changes, and the organic compounds were apt to deteriorate on stowage. Many of the chemical extinguishers proposed were toxic in themselves; that was the objection to carbon tetrachloride which was effective in small fires. The flames of shallow-burning pools could be extinguished with sand and with sawdust. Fires in large tanks were, at Hamburg, prevented by introducing carbon dioxide into the closed storage vessels for oil and petrol. Excellent results had been obtained with the foam mixtures, first used by the Prussian fire brigade and largely adopted in America. Two solutions are required, it will be remembered, viz., soda and acid sulphate of aluminium, to which frothing ingredients are added; the acid corrodes the pipes and short pipe connections are needed for various reasons. There is thus further scope for the ingenuity of the engineer in the perfection of the foam plants as well as in other fields of oil fire prevention and suppression and in the petroleum technology generally.

UTILISATION OF BROWN COAL IN GERMANY.

The isolation of the Ruhr coal and industrial area from the unoccupied parts of Germany is already dislocating German industry, and if prolonged for any considerable period, will tend seriously to cripple German trade, and bring impoverishment to her people. The Ruhr coal field has been the source of a very large proportion of the fuel needed for the German industries, and especially for the supply of metallurgical coke for use in the iron smelting blast-furnaces. The field is also important for its local significance. Many of Germany's industries are centred on this coal-field, and even if abundant and equally good coal existed in some other, but more or less remote, part of Germany, it could not adequately take the place of Ruhr coal, because of the transport problem.

The motives underlying the action of the French in occupying this area need not be discussed here. The present purpose is to show that important as the Ruhr coal field appears to be to Germany's industrial life, there is abundant fuel available elsewhere in Germany in the form of brown coal, or lignite. The reserves of brown coal in Germany, according to figures supplied in *Coal Resources of the World*, in metric tons are as follow:—

	Proved Reserves.	Probable Reserves.
Prussia and North Germany	6,070,000,000	3,676,000,000
Saxony	3,000,000,000	very large
Bavaria	75,000,000	293,000,000
Hesse	170,000,000	99,000,000
	9,315,000,000	3,968,000,000

In estimating these reserves, the authorities point out that the figured totals must not be taken as conclusive evidence as to the amount of brown coal in Germany, which is, without doubt, much greater. The figures given merely represent estimates of

quantity so far as borings and other exposures have made a figured estimate possible. This brown coal has a low calorific value, due almost entirely to the large amount of water it contains (approximately, 50 per cent.). When dried, the calorific value is not greatly less than that for good coal.

In most countries of the world, and particularly where hard coal deposits are abundant, brown coal or lignite has hitherto been regarded as too low in grade to be seriously considered as a fuel. But careful observers will have noticed that Germany although well provided with hard coal, has yet been making a steadily-increasing use of her brown coal. The outputs of both bituminous and brown coal at various periods taken from figures given in *Mineral Industry* are given below in metric tons :—

	Bituminous coal.	Brown coal.
1906	137,117,926	56,419,567
1913	190,109,400	‖ {87,233,100
1919	116,707,234	{93,648,264
1921	145,601,000	123,011,000

The output figures for 1922 are not yet officially published, but the lignite output is said to be about 140,000,000 metric tons. So far as these figures go, it looks as if brown coal is more and more taking the place of other coal in Germany, and it is interesting to enquire as to what uses this material is applied. A German explanation of the present large output of brown coal is that the requisitions for hard coal for France, Belgium and Italy under the Peace Treaty, make it necessary. This, if true, is not all the truth, and certainly fails to account for the large output in pre-war days. The real truth seems to be that it is only in recent years that the Germans have come to realise that in their brown coal reserves they have not only a valuable fuel, but that the large quantity of volatile matter in this material compared to that in her hard coal constitutes an asset of enormous potentiality.

The manner in which Germany has hitherto used her lignites has not been the subject of great publicity. It seems almost as if those exploiting it have not been anxious to inform the world as to their methods. Gradually, however, information is leaking out, and it is possible to-day to obtain even minute details. To a large extent the brown coal is used in its raw state, both in the form of untreated material or after briquetting. In the latter form it is an excellent domestic fuel well adapted for the German system of domestic heating, while in the powdered form and used like pulverised coal, it is a good fuel for industrial purposes. In the latter form it finds numerous uses, including steam generation, cement burning, as fuel in central power stations, lime and brick manufacture, &c. For briquetting, the material is dried in an effective and ingenious drying apparatus until the water-content is reduced to about 15 per cent., after which it is subjected to high pressure in a briquetting machine which turns out a solid and readily transported fuel. No binding agent is necessary in the briquetting operation as the bituminous matter in the coal acts as a binder. The central power stations supply a wide range of industries with the power they require. An interesting example is the supplying of the large amount of current required for two large aluminium reduction plants. In these plants purified alumina is reduced to metal electrolytically in a bath of fused cryolite, which is the solvent for the alumina. The current required for aluminium reduction is very considerable, and in other countries aluminium reduction works depend upon cheap hydro-electric power for this operation.

Of still greater interest is the use of brown coal as a source of benzine and petroleum substitutes generally. So far as can be ascertained, the liquid products of distilling brown coal amount to about 6 per cent. of oil, fractioning into motor spirit, lubricating oils, gas and fuel oils, and similar products. Other products are wax, pitch, and by-products resembling more or less those obtained in the destructive distillation of ordinary coal, but in much greater abundance.

Inasmuch as 60,000 metric tons of oil can be obtained from each million tons of brown coal distilled, it is only a question of duplicating plants for Germany to become quite independent of extraneous sources for motor spirit and other petroleum products, which hitherto it has been necessary to import in very large quantities. How far these home-produced materials have taken the place of imported petroleum products cannot be easily ascertained, but something may be inferred from the following import statistics taken from *Mineral Industry* :—

	1911.	1920.
Imports of petroleum products into Germany in metric tons...	1,215,724	425,529

These figures seem to indicate that Germany now has domestic sources of petroleum or petroleum substitutes of very considerable importance. There is good reason to think that the principal source of the home production is the distillation of brown coal.

One important by-product of brown coal distillation is sulphate of ammonia, the well-known fertiliser. The production of this substance, together with the synthetic nitrate process which has been developed, seems likely to make Germany independent of imported nitrates in the future. The residue which results from the distillation of brown coal is a semi-coke which still contains enough volatile matter to be a freely-burning fuel. This also finds use both as a pulverised fuel and also in the form of briquettes. In the case of this material, a binding agent is necessary in the briquetting operation, and this is the tar or pitch obtained in the distilling stage. Lignite both in the raw state and as semi-coke is used largely for making industrial gas. If completely gasified, as is often practised, the yield of gas is large and the calorific value satisfactory. For gas-making purposes it is stated that lignite is the cheapest raw material available.

It is of interest to note that the French, although favoured with large brown coal deposits and somewhat sparingly supplied with hard coal, have made little headway in utilising their brown coal resources. The current output of this material mined in France is considerably below a million tons per annum compared to Germany's output of about 140,000,000 tons. This has been the subject of severe criticism by A. Guiselin, a French engineer, in an article on the subject which appeared last June in *Chemie et Industrie*. The writer of the article calls attention to the fact that Germany's research in regard to her brown coal may result in a great surprise for the world generally, and France in particular. He states that the discovery of the German, Dr. Bergius, by which coal and other solid carbonaceous material can be converted into liquid hydrocarbons by moderate heat in the presence of highly-compressed hydrogen, finds in brown coal an ideal raw material. The weakness of the process hitherto has been the very large amounts of hydrogen to be provided for combining with the carbon to form the hydrocarbons, but it has recently been found that methane (CH_4) can take the place of the hydrogen in the process and is itself converted into a liquid hydrocarbon. The significance of this development of the process lies in the fact that the distillation of lignite, or brown coal, yields large quantities of methane gas, this with the hydrogen, forming about one-third of the gaseous mixture given off in the retort. It seems feasible, therefore, to use the gas given off by distilling one portion of brown coal to liquefy another portion. There is no doubt that the successful development of this process, which seems assured, will have a profound effect on the future of oil supply and by-products, and it is not surprising to find that it is creating world-wide interest. Amongst others who are investigating its possibilities is the British Fuel Research Board.

The question of the utilisation of brown coal as a blast furnace fuel appears to be worth consideration. The semi-coke resulting from brown coal distillation seems to be a possible fuel if used in the briquetted form. Carbo-coal, as made in the United States, involves the distillation of the briquettes after they are pressed, which cokes the binding material and results in a hard smokeless fuel. Some such treatment for the semi-coke briquettes seems worth a trial. The cost of this second distillation is said to be more than recovered by the value of the volatile matter obtained. Brown-coal fuel of this character contains a somewhat high-ash content. It is conceivable that this ash, unless too high in sulphur, could take the place of a portion of the fluxing material forming a portion of the blast-furnace charge. This suggestion, which, however, is not based on actual experiment, but is only given for what it may be worth.

One form of the electric smelting of iron-ore practised in Sweden, is practicable with powdered fuel. This also has a bearing on this question. More might be said of the possibilities locked up in brown coal if space permitted, but enough has been said to show that such a material in the hands of a resourceful people like the German nation, can be made to serve most purposes for which a fuel is required. In view of these facts, it would be premature to conclude that the permanent loss of the Ruhr coal-field would be an irreparable disaster to Germany. The utilisation of German brown coal is no mere experiment. It has long since passed out of that stage and now forms the basis of large and prosperous industries. Moreover, with every year's experience, the material must become of greater utility.

WATER POWER DEVELOPMENTS IN THE UNITED STATES.

SOME idea of the extent to which water power is being utilised in the United States is afforded by the First and Second Annual Reports of the Federal Power Commission. These two reports, the latter of which has only recently been published, cover the activities of the Commission from the date of the approval of the Federal Water Power Act in June, 1920, up to the end of June, 1922, and therefore form a synopsis of the work of the Commission from its inauguration to the latter date.

Owing to the long delay in securing adequate Federal legislation it was only to be expected that the passing of the Federal Water Power Act would result in a flood of applications for licenses to develop the many excellent water-power sites which exist throughout the States. During the period covered by the First Annual Report applications aggregating no less than 15,000,000 h.p. of proposed installation were received by the Commission, while during the fiscal year ending June 30, 1922, further applications to the extent of over 5,000,000 h.p. installed capacity have been filed, the total number of applications involved being 321. The aggregate of over 20,000,000 h.p. covered by these applications is more than twice the existing water-power installation of the United States, and is almost six times greater than the aggregate embraced in all the applications for power sites received during the preceding twenty years. Nearly one-half, however, of the total power included in the applications in question is represented by proposed power-development schemes on the St. Lawrence, Columbia and Colorado rivers, and in all these cases action has been suspended. In the case of the St. Lawrence international relations with Canada are involved, and a treaty may be necessary before action can be taken, while all decisions in the case of the Columbia River have been deferred pending the findings of a special board which is investigating the relation between irrigation, navigation and water-power development upon that waterway. Negotiations between the various States within the Colorado basin necessitate the postponement of the issue of specific licenses in the case of this area. In spite, however, of the fact that decision has been deferred in respect to nearly one half of the power covered by the applications received by the Commission, definite action has been taken on more than half the total number of applications received during the two years under review. While there have been delays in certain other instances in arriving at a decision, such delays have usually been due to the infeasibility of the projects for which applications have been made.

Up to the end of June, 1922, the Commission had authorised 58 preliminary permits and 49 licenses, of which 18 were for transmission lines. The 58 permits outstanding at the date in question involve an estimated installation of 2,405,975 h.p., and the 31 licenses for power projects 1,945,245 h.p., or a total of 4,351,220 h.p. Of the various projects covered by the licenses 27 were either completed or under construction, the estimated installation involved being 1,951,800 h.p. Of these the most important are the developments being undertaken by the Niagara Falls Power Company and the Southern California Edison Company. The first

of these, which is at present under construction on the Niagara River in the State of New York, involves primary power to the extent of 341,500 h.p., and an installed capacity of 572,230 h.p., and when completed will represent a capital investment of nearly 70,000,000 dols., while in the case of the second the primary capacity will be about 158,000 h.p., the total installed horse-power about 545,000, and the total cost over 60,000,000 dols. Other important works at present under construction include the development of the Southern California Edison Company, on the San Joaquin River, which will have an installed capacity of 195,000 h.p., and will involve an expenditure of about 13,000,000 dols.; the Coosa River scheme of the Alabama Power Company, which is being constructed for an installed horse-power of 100,000 at an estimated cost of about 11,000,000 dols.; and the undertaking of the Wisconsin-Minnesota Light and Power Company, which involves an installed capacity of 20,000 h.p. Two other important schemes, upon which work had not been commenced during the period covered by the Second Annual Report of the Commission, but for which licenses had been issued during the year, are the proposed development of the San Joaquin Light and Power Corporation on the King's River, California, and the Portland Railway Light and Power Company's scheme on the Clackamas River, Oregon. The former involves a primary power capacity of 161,000 h.p. and an installed capacity of 266,000 h.p., and will cost in the neighbourhood of 51,000,000 dols., while the latter, will have an installed capacity of 30,000 h.p. and will involve an outlay of over 3,000,000 dols. Another important project which is at present being carried out and which will involve an expenditure of about 14,000,000 dols. is that of the El Dorador Power Company on the South Fork of the American River, California, the primary horse-power in this case being 30,000, and the total installed capacity 100,000 h.p. The balance of the 1,951,800 h.p. for which licenses have been issued is made up of comparatively small installations, the capacities involved ranging from 6,000 h.p. down to less than 100 h.p.

Some indication is afforded by the foregoing figures of the rapidity with which hydro-electric power is being applied to industrial purposes in the United States. Although it will doubtless be found that a great deal of the power included in the aggregate of 20,000,000 h.p. for which applications have been filed during the past two years is incapable of development on a commercial basis, and although up to the present licenses and permits covering only a little more than one-fifth of this aggregate have been actually issued, it is probable that during the next few years new power approaching an installed capacity at least one-half of this total will be put into operation. In view of this it is evident that the work of the Federal Power Commission will be no sinecure. That there is some doubt as to the ability of the Commission, as at present constituted, to deal in an entirely satisfactory manner with the volume of work which may be expected is clear from the Second Annual Report. The duties of the Federal Power Commission and the circumstances under which it was expected to carry them out, were discussed in a previous article.* By the terms of the Federal Water Power Act, the Commission is called upon to investigate all projects in respect to which applications are received; to determine whether the project is feasible from both the engineering and financial standpoints; and to decide whether the proposed structures are safe and properly designed, and whether full utilisation will be made of the power resources of the stream. It is also required to make valuations of all properties licensed under the Act and constructed prior to the issue of the license; and to establish for its licensees a system of accounting whereby the net investment in the properties may be known at any moment, It has many other duties in connection with the administration of the water-power resources of the country. To deal with this work the Commission has been assigned an executive secretary and an engineer officer, and is obliged to borrow for its work such *personnel* as other departments are willing to loan. Under these circumstances the Commission has been compelled to delay action on many important projects and to omit altogether the performance of many of the duties required by the Act. Naturally such conditions do not tend to assist in the rapid and efficient development of the water resources of the country; and the reports emphasise, not without reason, the urgent necessity of more adequate administrative machinery in order that the duties imposed upon the Commission by the Act in question may be carried out expeditiously and effectively. At present nearly all the field work involved has to be carried out by the district engineers of the Engineer Department, the Geological Survey and the Forest Service, and as the officers concerned all have their own departmental duties to perform it is only natural that the work which is placed upon their shoulders by the Commission should be regarded as of secondary importance. Although the departments concerned appear to have co-operated with the Commission in a very hearty manner, it is felt that the work involved in the exploitation of the water-power resources of the country should not be made subservient to any other, and that to carry out satisfactorily its duties the Commission should have its own technical and clerical staff. In view of the enormous water-power available in the United States, and of the vast wealth which will accrue to the community by its effective development it would certainly seem that there is sound reason for the contention that the necessary machinery for administering the Federal Water Power Act should be placed at the disposal of the Commission.

* ENGINEERING, Vol. civ., page 114.

ATOMIC PROJECTILES AND THEIR PROPERTIES.

AT the Royal Institution on Saturday last, Sir Ernest Rutherford, F.R.S., delivered the fourth lecture of his course on the above subject.

In opening his lecture, Professor Rutherford said that on the last occasion he had given an elementary account of the properties of the α particle, pointing out that it had more energy than any electron yet known to us, and that its passage through a gas was marked by very intense ionisation, which could be demonstrated both by electrical methods and by Mr. Wilson's plan of photographing its trail through supersaturated air. The α particles had, moreover, the peculiar property of possessing a definite range in air or other gases at normal pressure and temperature. He now proposed, in the first place, to deal with the explanation of the ionisation produced along the path of the particles. The α particle must, he said, be regarded as carrying two charges of positive electricity, and when fired out from a radioactive body had a speed of some 20,000 km. per second. Taking the range in air as some 7 cm. the particle would in this distance pass through the structure of very many atoms. These atoms had themselves an electric structure, and consisted of a positively-charged nucleus surrounded by electrons. As the α particle came along at a high speed, it occasionally approached close enough to one of these electrons to give it an impulse, which at times was sufficiently strong to break the ties uniting the electron to its atom, leaving this atom ionised. At least 100,000 of these transformed atoms would be left behind the α particle during its career, and thus in Mr. Wilson's photographs we got a continuous line (see Fig. 21, page 308, *ante*) as representing the trail. On the other hand, as shown in the same figure, the high speed β rays were much less effective, so that individual ionisations might be seen in its trail.

How was it? the lecturer continued, that the α particles were so efficient and the β rays so inefficient as ionisers. The main reason, he said, was that the impulse communicated to an electron of any atom struck, depended on the time during which the electron was under the influence of the force tending to displace it. Thus the faster an α particle went the less time it had to communicate momentum to electrons near which it passed, and in accordance with this, observation showed that such particles were least efficient at the commencement of their career, when their speed was at its highest. The β particles travelled some 20 times as fast as the α particles and moreover carried only one charge instead of two, but the main point was that in view of their very high speed it was but very rarely that they were able to act on the electron of an atom for sufficient time to transfer to it enough energy to make it escape from its atom.

When an α particle went past an atom it occasionally went right into the atom's inner structure, reaching and displacing the tightly-bound inner electrons, and drove them out, often with such a surplus of energy that they were themselves capable of producing further ionisation. This was well shown in Fig. 24, due to Professor Bumstead, of Yale, where little side chains could be seen alongside the main track of the α particle. Each of these side chains indicated the expulsion of an electron from an atom, with sufficient energy for it to act as an ioniser on its own account.

It might be asked whether matters were really quite as simple as had been represented, and whether

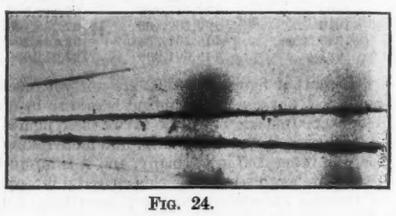


FIG. 24.

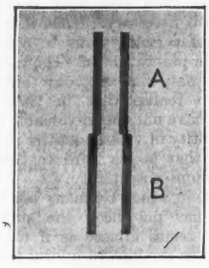
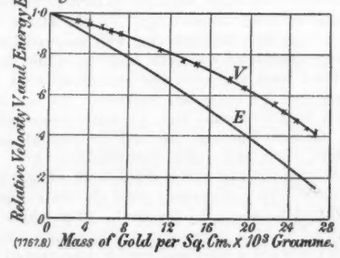


FIG. 25.

Fig. 26.

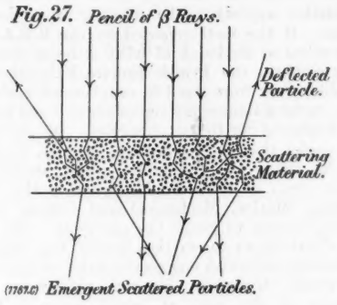


the α particle did not knock more than one electron out of the atoms it encountered. This question had been examined by Millikan, who found, that in ordinary air or other common gases, the α particle appeared to remove one electron only from the atoms it struck, but that when helium atoms were bombarded, in about 20 per cent. of the total collisions both the electrons were removed from the helium atom. This helium atom had a mass of 4 and had but two electrons which were K electrons. Apparently these K electrons were so interconnected that when one was removed there was a fair chance that the other would also be carried away. This double ionisation was most likely to happen when the α particles were moving relatively slowly. The speaker believed, that two electrons were sometimes knocked out of an oxygen atom, but the proportion of cases in which this happened was so small that it would be very difficult to detect.

Assuming that as stated the α particle went through some 100,000 atoms, ionising them, it must lose energy in the process, and be slowed down. This slowing down could be readily measured by determining the deflection of the particles when they were made to pass through a magnetic field. This deflection was inversely proportional to the speed of the particle. If a screen of definite thickness were interposed between the source of the rays and the deflecting field, the particle being slowed down by

passing through the screen was deflected more than it otherwise would be. The deflection was measured by allowing the particles to impinge on a photographic plate. In Fig. 25 the distance between the bands marked A showed the deflection obtained when there was no screen between the source and the deflecting field, whilst the bands marked B showed the effect of the screen. The speaker had made experiments of this kind in 1903–1904, and in Fig. 26 are shown some results obtained by Marsden using screens of gold. Thes topping power of a gold leaf weighing 4·3 milligrammes per square centimetre was equal to that of 1 cm. of air, and it could be seen that very consistent results were obtained with the gold leaf up to a thickness corresponding to about 6 cm. of air. Beyond this limit measurement became difficult. By using screens as described it was possible to get α rays moving with any desired velocity.

Fig.27. Pencil of β Rays.



(7767.2) *Emergent Scattered Particles.*

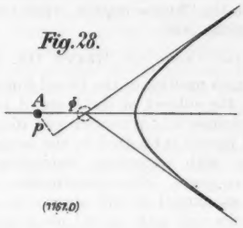
When the α particle passed through an atom knocking out an electron, there was, of course, a reaction also on the α particle, which would thus be deflected slightly first in one direction and then in another. Thus we might expect α rays to be scattered when they passed through matter. On the rare occasions in which the α particle got close into the nucleus it met with a much stronger field than when it merely passed near the outer electrons, and it was therefore subjected to a much stronger deflecting force. The β rays were also scattered in passing through matter, but as they were very much lighter, the scattering was much more marked, and in fact quite a large number of them were, as the result of successive deflections, turned back in their course as indicated diagrammatically in Fig. 27. Many β rays thus emerged from the screen on the same side as that on which they entered, the effect being much the same as if they were reflected. Actually, however, the phenomenon was not a surface effect like reflection, but was due to a succession of deflections in the interior of the screen.

Very similar results were observed with α rays, but these having much greater energy were more stiff and difficult to deflect, and were thus much less scattered. Still the accumulation of the small deflections experienced as they passed through matter was very easily observed by interposing a screen in the path of a pencil of α rays impinging on a zinc sulphide screen. The spot of phosphorescence produced on the zinc sulphide, immediately became more diffuse. The effect of these cumulative small deflections on α rays was, however, small. the maximum deflection thus produced being only a few degrees. It was found, however, that when a sheet of gold was bombarded by α particles there were always some which were scattered through large angles, and, in fact, some individuals came back almost in the direction from which they started. The important point was, that experiment showed that these large deflections were not cumulative effects, as in the corresponding case of the β rays, but were the effects of single collisions. Theory showed that the probability of these large deflections was incredibly remote unless the positive charge of the atom were concentrated into a minute nucleus, and it was in fact the observations made on these large deflections of α rays which led to the formulation of this view of atomic structure.

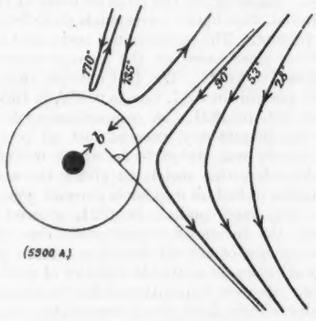
Accepting this view, an α particle which (by a very rare chance) passed close to the nucleus of an atom, would find itself in a region where there were no electrons. The α particle carried two positive changes and the atomic nucleus was also strongly positively charged. There was thus a repulsion between the two, and the α particle would accordingly be deflected into a curved path as indicated in Fig. 28. If Newton's law of force held, the orbit would be an hyperbola, the angle through which the α particle was scattered being lettered ϕ on the diagram. This diagram illustrated what might be anticipated when an α particle passed close to the nucleus in a region free from electrons.

It might be asked how could we be sure that the α particle would not be deflected in passing through the electrons on its way to this inner region? It should be borne in mind, however, that the α particle had a mass of 4, whilst that of the electron was about $\frac{1}{1805}$, hence the α particle, if it did collide with an electron was very little deflected, but when it reached the powerful field surrounding the

Fig.28.



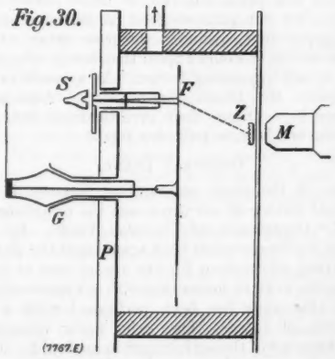
(7767.0)



(5300 A.)

FIG. 29.

Fig.30.



(7767.1)

massive nucleus of the atom its motion was greatly affected. In Fig. 29 various orbits had been plotted corresponding to different cases of a "collision" with an atomic nucleus. The higher the speed of the α particle the closer it could get to this nucleus. The chance of a deflection through a large angle was however less, the faster the particle.

It was necessary to get away from the idea that such collisions as these were impacts in the ordinary mechanical sense. The α particle was deflected by an invisible field of force of very great magnitude. The ordinary laws governing ordinary mechanical collisions, nevertheless, did hold perfectly in this domain of atomic collisions, both momentum and energy being conserved. The number of collisions made, however, did depend on the forces acting between the α particle and the nucleus, the frequency with which a collision occurred depending on this.

Theory showed that the number of α particles deflected through a large angle was proportional to $\operatorname{cosec}^4\left(\frac{\phi}{2}\right)$ and also to $(N\ e)^2$, where N denoted the number of positive charges on the nucleus. A comparison between theory and experiment had been made with the apparatus illustrated in Fig. 30. A source such as radium C was placed at S, and a screen at F. Of the particles passing through this screen, some few were deflected through large angles. They struck a zinc sulphide screen at Z, and the number falling on a square centimetre per second was counted with the aid of the microscope M. This could be moved up and down to correspond to different angles of deflection, and measurements could be made in this way up to angle of 70 degs. or 80 deg. Comparing thus the relative numbers

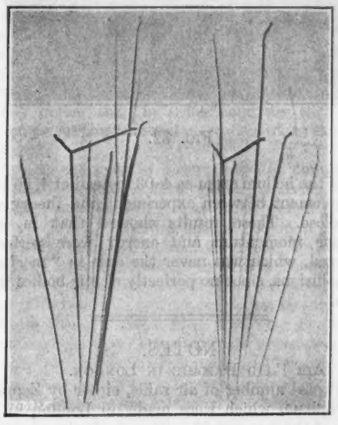


FIG. 31.

for different angles with the number calculated by the formula given, the theory was confirmed and this theory was based on the inverse square law of force. The theory also showed that the number of deflections through a large angle should be proportional to the square of the atomic number and this conclusion was also confirmed by experiment.

It would be seen that there was no reason why in certain cases the α particle should not be turned completely back in its track and no doubt this event did occasionally occur.

Thus far, Professor Rutherford continued, he had been concerned with the collisions of α particles with fairly heavy atoms. When the collision took place with lighter atoms, such as those of oxygen or nitrogen, the atom struck was itself sensibly displaced, and might produce a trail in supersaturated air just as did the α particle itself. Some very notable obseravtions of this kind had recently been made by Mr. Blackett at the Cavendish Laboratory. Mr. Blackett took simultaneously two photographs in planes at right angles to one another, so that from measurements of the trail angles in both photographs he could determine the true angle in space of the trail left by the atom struck and by the α particle after the collision. From the ordinary laws of mechanics, the angle between the trails could be calculated from the relative masses of the atom struck and of the α projectile. A collision between an α particle and an oxygen atom is represented in Fig. 31, which shows the two photographs taken as stated at right angles to each other. Measurements of the angles in this photograph made it possible to determine the actual angle in space which the trails formed with each other, and from this the mass of the particle struck could be calculated, In this instance the mass came out as 16·72 with a probable error of 0·42, as compared with the true value of 16. Interesting results were obtained when the α particles were fired through helium. The α particle was itself a charged atom of helium, and hence the two bodies involved in the collision had the same mass. From the ordinary laws of mechanics it could be proved

that if two perfectly elastic spheres of equal mass collided the subsequent paths necessarily made a right angle with each other.*

Photographs representing a collision between an α particle and a helium atom were reproduced in Fig. 32. Mr. Blackett's measurements gave the angle as 89 deg. 40 min. instead of 90 deg., and the

FIG. 32.

mass of the helium atom as 4·03 instead of 4, so that the agreement between experiment and theory was very close. These results showed that in such collisions momentum and energy were perfectly conserved, which was never the case in "mechanical" collisions, since no perfectly elastic bodies were known.

NOTES.

AIR RAID DAMAGE IN LONDON.

The total number of air raids, either by Zeppelin or aeroplane, which were made on London in the course of the war was 25. They took place between May 31, 1915, and May 20, 1918, and resulted in the deaths of 524 people and injury to 1,264 others. These are the official figures of the London Fire Brigade, and although their completeness presumably cannot be guaranteed they may certainly be taken as approximately accurate. In the course of these raids 174 buildings were destroyed and 619 seriously damaged, involving a direct monetary loss of about 2,042,000*l.* These figures are given in Red Book No. 240 of the British Fire Prevention Committee which has just been published, and which gives an interesting survey of the subject generally, together with illustrations and detail information in reference to some of the cases of damage. Although 524 deaths and 2,042,000*l.* worth of damage are serious items which there is no value in minimising, it may none the less be admitted that in view of the density of population and buildings on the area attacked the results from the point of view of the enemy were small. As pointed out in the record the cases of direct damage to structures of national importance were rare, although as closely as can be estimated 355 incendiary and 567 explosive bombs were dropped. The British Fire Prevention Committee is naturally chiefly interested in the subject in its fire aspect, but the publication deals with the question of air raid shelters and points out that an examination of the records shows that a series of floors of concrete, or reinforced concrete, affords very considerable protection, and indeed on the lower floors absolute immunity against the average explosive bomb and almost entire protection on any floor against incendiary bombs.

TECHNICAL EDUCATION AND THE BOXER INDEMNITY.

An understanding has been come to between Great Britain and China that the balance of the Boxer Indemnity which is still due to us shall be devoted to educational work, mainly among the Chinese younger generation. The balance amounts to 11,186,547*l.*, which is equivalent to about 400,000*l.* a year for twenty years. The Textile Machinery Makers' Association, which has for some time been formulating plans for the establishment of a textile technical school in China, has decided to appeal for general support of the scheme and to ask the Governments concerned for a share of the annual allocation to be made in connection with the indemnity. This scheme, while helping the Chinese themselves, should considerably assist British trade. The school would probably be placed in Shanghai, and the estimated cost of the land, building and equipment is 150,000*l.* It is estimated that the annual cost of upkeep would be 17,000*l.*, and, as students' fees are not expected to bring in more than 2,000*l.* a year, there would be an annual deficit of 15,000*l.* to be met. The scheme would provide for the practical education of between 300 and 350 students in the use of British-made textile machinery and should attract orders to this country. Somewhat similar activity on the part of the United States has greatly increased the sale of American textile machinery in the Chinese market, while Germany is also entering the field.

THE WORKING COSTS OF HEAVY OIL ENGINES.

AT the March meeting of the Diesel Engine Users' Association, the subject of the costs of running of heavy oil engines was reviewed and discussed on the basis of figures submitted to the committee by undertakings with experience extending over a period of five years. Six representative organisations, with an annual output amounting to about 1,000,000 units and with annual plant load factors of at least 15 per cent., showed a total cost of 1·08*d.* per unit. Allowing for the reduced costs of labour and material, that figure corresponds to 0·789*d.* per unit at present. The maintenance costs used in the calculations were based on the average experience of the last five years. The fuel charges amounted to 0·52*d.* per unit in 1917, rose to 0·67*d.* in 1920 and fell to 0·53*d.* in 1921. In comparison with these figures the present-day average fuel oil costs for Diesel engines was stated to be about 0·33*d.* per unit. An interesting statement giving the average consumption of fuel oil in pounds per unit generated for the five years ending in 1921, showed very distinctly the increased consumption due to the compulsory use of tar oil during a certain period of the war, when all available supplies of petroleum and shale oils were requisitioned for the use of the Admiralty. From India the figures relating to heavy oil engine installations showed results for stations on the seaboard, with a consequent supply of fuel oil at a low price, superior to those obtained in Britain, but not quite so good for inland schemes. In that territory, owing to the poor nature of the coal available, it would appear that heavy oil engines have a very promising future. As a result of the discussion, the Diesel Engine Users' Association propose to continue their investigations into this question and later to publish a report.

OVERSEAS TRADE.

One of the most outstanding features in the political history of our times was the establishment of the Department of Overseas Trade. By this action the Government took upon itself the duty of collecting information for the trader and of facilitating his work in connection with contracts abroad. That this work has been performed with a fair measure of success those who know thoroughly the character of the activity are in no doubt. There is still, however, a large number of the trading public who remain ignorant of the value of the services rendered, either because of lethargy or a suspicion that the services of a Government department can never be for the benefit of business. To such we recommend the perusal of a small book on its work issued by the Department of Overseas Trade, when under the control of Sir William Joynson-Hicks, Bart. Copies of this may be had from the offices of the department, at 35, Old Queen-street, Westminster, S.W. 1. In all the work engaged in by the organisation, the underlying principle is to assist trade without interfering with it. There are many who are familiar with the valuable annual reports on the trade and economic conditions of the various countries of the world, but few have a knowledge of all the fields of service of the department. Information for the service of traders is collected by Trade Commissioners in various parts of the Empire, and by the Commercial Diplomatic Service in foreign countries. This information is published in the *Board of Trade Journal*, and through the general press. When the information is of a confidential nature or should not become available to foreign competitors, the firms on the Special Register of the Department doing business of the particular character are communicated with direct. Brief chapters of the book deal with the system of export credits, trade guarantees, and other forms of activity. The objects of the department are severely practical, in the achievement of which it has the assistance of a strong Advisory Committee of business men.

BRITISH EMPIRE EXHIBITION.

The scheme of classifying exhibits for this great national enterprise into sections, and entrusting the organisation within each to representative institutions such as the British Engineers' Association and the British Electrical and Allied Manufacturers' Association appears to be meeting with desired success. If the facts reported by the B.E.A. are to be taken as an index of what is being done in other sections, the British Empire Exhibition, at Wembley Park from April to October, 1924, should prove to be a thoroughly representative and extensive display of our British industries. One has only to consider that the applications already, fourteen months before the Exhibition opens, amount to 62 per cent. of the available space in the Shipbuilding, Marine, Mechanical and General Engineering Section to gauge the prospects. The first list of exhibitors shows that nearly two hundred representative British engineering firms have already interested themselves in the exhibition, and in view of the rate at which space is being claimed, early application for the residue by those who desire to be represented, is advisable. There are fourteen sub-sections comprised in the section organised by the British Engineers' Association, namely:—Iron and steel, non-ferrous metals, machine tools and workshop equipment, power generation, shipbuilding and marine engineering, locomotives and tenders, agricultural machinery, textile machinery, general manufacturing machinery including printing plant, constructional engineering, mining and metallurgical plant, gas and chemical plant, general engineering, and mechanical munitions of war. The space available for this section amounts to about 200,000 sq. ft. in the Machinery Hall and the Industrial Hall, the structures of which will be completed in August, so that ample time will be available for the erection of the displays. These two halls alone cover an area of more than four times that of Olympia. We understand that the B.E.A.M.A. Committee are also experiencing a great demand for space in the Electrical Engineering Section, and that no time should be lost in making applications.

THE THERM.

The therm, which has caused such an exhibition of absurdity on the part of a section of the general public and the lay press, may trace its official connection with towns' gas supply back to 1909, when the Gas Light and Coke Company became subject to an Act of Parliament requiring it to supply gas to a calorific standard. Further legislation followed in 1916 when owing to the exigencies of the war, an Act was passed to meet the condition of those companies which, following the stripping of gas for the removal of benzol and toluol, found it impossible to maintain their illuminating standard. In 1907 the Board of Trade requested the Fuel Research Board to inquire into the matter generally, and as a result of their recommendations the Gas Regulation Act of 1920 was passed. This Act requires gas to be sold by its heating value and not by its bulk, so that while gas companies are left free to produce the most suitable gas which local conditions may dictate, the consumer is protected from having to pay for incombustible diluents. Partly, no doubt, as a result of genuine stupidity, but partly probably also with some formless idea of attacking gas companies, a section of the public and press raised such an outcry when this calorific system of charging was introduced, that the Board of Trade thought it desirable to appoint a committee to hold a public inquiry into the therm system of

* A limiting case arises when the centre of the sphere struck lies directly in the line of motion of the moving sphere. In that case the colliding particle remains stationery, transferring the whole of its momentum to the "object ball."—Ed. ENGINEERING.

charging. This committee has just reported. It is hardly necessary to say that the committee found it "abundantly clear that the system of measurement by the therm, as such, can in no way affect the price, composition, quality, pressure or supply of gas." In view of the history of this question this pronouncement is evidently necessary, but it would appear more suitably addressed to the lower forms of an elementary school than to a supposititiously educated public and press. One trusts this may be the end of the matter. A genuine question which is dealt with in the report is whether a consumer obtains equal value for each therm, whether it is obtained from gas of a low or high calorific value. The conclusion is that over a wide range of calorific values the heat value of a therm to the consumer is substantially the same for heating, cooking or lighting. This verdict is, of course, subject to the condition that the consuming appliances are adjusted to suit the gas—a very important point.

LITERATURE.

Mechanical Testing. Vol. II. *Testing of Prime Movers, Machines, Structures, and Engineering Apparatus.* By R. G. BATSON and J. H. HYDE. London: Chapman and Hall, Limited. [Price, 25*s.* net.]

TESTING the materials, of which any structure or machine is composed, with a view to finding whether their use in the work will prove satisfactory, is a part of the policy of every engineering concern. An equally important class of work undertaken by the constructors of industrial plant and equipment is to determine the output and efficiency of the completed machine. This natural division of the subject of testing has been adopted by the authors of this work, the matter being treated in two separate volumes.

The second volume which has just been issued completes the work and in the test work covered by its contents there are two distinct fields. The first is in research work, where the endeavour is to determine the effects of all conditions of operation or of construction in order that uneconomical use of material may be avoided, greater efficiency obtained and the costs of operation reduced. The other class of work is that of commercial testing performed for the purpose of providing proof that the machine satisfies the intentions of the designer and the demands of the purchaser with regard to output, satisfactory working and the consumption of the natural resources which it utilises. As the purpose of these two types of test work is essentially different, so the methods adopted and the types of instruments used, show marked dissimilarities. In the investigator's work after the early trial of the apparatus it happens quite commonly that certain departures have to be made from the original design owing to the recognition of unexpected behaviour of the plant or specimen under test. In such work the direct-reading type of instruments may find little employment, and reliance is placed on calibration tests of the devices used. For standard tests and for commercial work, which may have to be conducted by people with little skill as experimenters, direct-reading instruments are almost essential, and wherever zero adjustments must be made, there should be such provisions as to make the operations very simple of performance. There is much to interest the workers in both of these fields of testing work in this volume although the greater part of the book is devoted to standard instruments, the methods of, and the results obtained from their use.

The authors have kept to the title of the work very rigidly during the planning of the scheme of work. To them the mechanical testing of prime movers means only the determination of the useful power available, and those who look for a discussion of arrangements suitable for fuel, steam or gas measurements, technical thermometry, analysis of flue gases or the exhaust from internal-combustion engines or even the determination of indicated horse-power will be disappointed. The determination of useful power or torque is, of course, a fundamental matter to the commercial testing engineer, and the volume is amply provided with descriptions of a very representative collection of absorption and transmission dynamometers. Not only are purely mechanical devices referred to but also some types of electrical apparatus.

In all test work it is desirable if not essential to perform the work with the plant running under conditions comparable with those of actual working. As an example of this, aeroplane engines should be tested in such a way that the cooling effects of the air when in use should be artificially reproduced. The use of fan brakes may achieve this purpose, but their use must be limited to some standard environment for which the constants to be introduced into the calculations are known. The usual arrangement adopted in such a case is, however, to create the draught by a fan which forms no part of the power absorbing system. Another condition of running introduced into this class of work is the provision of a thrust on the crankshaft comparable with that produced by the aerial propeller.

Chapters of the book are devoted to such types of work as testing gears and springs, lubrication, friction tests on bearings, vibration investigations, balancing, testing concrete slabs, reinforced concrete beams and complete steel structures and cutting tools. In the section of the volume dealing with lathe tests it is surprising to find not even a passing reference to the classical work on this subject conducted by the late Professor John T. Nicolson. As both the authors are members of the staff of the National Physical Laboratory, there is naturally a large amount of space devoted to work performed in that Institution. The volume is valuable as it brings together much of what can only otherwise be found in the original publications, and to these there are ample references to aid those who seek further information.

Industrial Organisation, Development and Prospects. By JOHN LEE, M.A., M.Commr. Sc. London: Sir Isaac Pitman, 1923. [Price 5*s.* net.]

THIS thoughtful essay is founded on a series of lectures given by the author, at Cambridge, in the autumn of 1922, under the auspices of the Board of Economics. The object of the promoters, apparently, was to spread accurate information concerning those schemes of industrial organisation that have been designed with the view of securing a more generous recognition of the claims of labour. This object should be achieved, for the author exhibits the present position of many problems that vex the labour world, and shows what has been accomplished by legislation and by individual and collective effort. He traces the influences that have been at work in many countries of Europe and America, and shows how national characteristics have led to the adoption or approval of a mechanism peculiarly suitable to the temperament of each, but with sharp dividing differences of detail that prevent these inchoate schemes, now on their trial, being blended into a common plan of organisation. It does not seem possible to forecast any solution that will prove generally satisfactory, and no attempt is made to define an ultimate scheme that will unite the warring interests of capital and labour.

Professor Lee has studied the working of many earnest, if misguided, attempts to effect a balance in the contributions of labour and capital in the common work of production, and his attitude is one of caution, perhaps reticence. The opportunity of sharing in his wide information, drawn from observations made both in Europe and America, gives to this work its peculiar value. With more knowledge comes greater tolerance, for we shall better appreciate all the difficulties that have to be reconciled, all the interests that have to be satisfied, and all the prejudices that have to be encountered. The author condemns no system that is administered honestly and unselfishly, though little sympathy or approval is meted out to the Soviet Control, whose operation is entrusted to directly interested parties, and "which possesses no moral stimulus and no personal interests."

Progress towards the desired goal will be most rapid and satisfactory when the path of least resistance is followed, and the movement accommodates itself to the development of political ideas and the environment resulting from long growth and custom. It is unwise to entertain an undue reverence for our own institutions and methods, or to imagine that any one scheme will satisfy all needs or all ambitions. The machinery that promises success in one country, if transplanted to another soil, may yield only a crop of disappointment and disasters. The pieces arranged on the industrial chessboard of Paris and Milan, of London and Berlin, may appear to a superficial examination to be similarly grouped, but the solutions of the several problems will be found to be grotesquely different. The rules of the game apparently vary. English caution and reserve demand a system of continual compromise, in which adequate trial is given to each step. The German, while prepared to submit to discipline and obedience asks for a logical plan from an organised bureaucracy. The French yield to politeness, consideration and tact, what might be refused to State interference, and an inelastic *regime*. American individuality, verging on eccentricity, fights shy of institutions that may imperil its treasured independence. The national tendencies of Italy have been atrophied by her long dependence upon German support, and when called upon to bear her own burdens, exhibited an impatience of control that was unexpected, but being less hampered by tradition and advice, this country will probably evolve a scheme that will fructify earlier than in other countries that have had longer preparation and more discordant elements to satisfy.

Through the maze of uncertainty and complexity the author treads a clear path, removing many obstacles and providing that fuller enlightenment without which comprehensive co-operation is impossible. The collection of facts assists the judgment in endeavouring to decide between the selfish motives of some, and the prejudiced utterances of others, who are anxious to see the old order violently changed simply from a sense of discontent, forgetting how easy is the work of destruction, how difficult the task of construction and replacement. Although a comparison between the degrees of development effected in various centres is difficult by reason of the conflict of rival forces, armoured in ignorance and burdened by passion, yet the author gives a qualified approval to the present organisation of French industry, considering that the present relation of different orders is on an exemplary footing. Other countries and factions are urged to study the spirit of industry cultivated in France. This spirit is attributed in great measure to the old paternalism, engendered by the *Conseils de Prud'hommes*, founded as far back as 1789, coupled with the reverence for the France of old, through all the changes of dynasty and government. That ancient spirit has a stabilising force, distrusting any organisation, however ingeniously conceived, that might undermine ancient tradition and supplant its claims.

Germany has a brand new Constitution since the war, providing the most closely-welded and most inclusive scheme yet attempted. It is an extension of a policy favoured by Bismarck, who saw advantages, from the point of view of an autocratic government, in creating an economic, or industrial, Parliament having powers equal to the political Parliament, believing that the best means of checking democratic power was to combine with it the responsibility of economic power. The scheme inaugurated in 1920, has much in common with that suggested in 1878 by Bismarck, but has by no means reached finality. Its main feature is one of compromise to the claims of capitalism and yet making some concessions to socialistic thought. The extension of a similar plan to England is not likely, for it is impossible to conceive that the British House of Commons would brook a rival claiming equal authority in any direction.

The systems in course of development in England come under criticism, but it is less necessary to refer to these as we all enjoy ample opportunities of collecting information. The tentative schemes adopted by many individual firms are reviewed in some detail, and the principles of trade unionism, the methods of co-partnership, the demands for admission to management and the objects of the Whitley system are considered with knowledge and discrimination. In the United States, the combination of Labour Councils, Works Councils and other devices for promoting harmony throughout industry do not appear to have crystallised into a

definite shape, from which clear indications can be drawn. Professor Lee regards the ameliorative and benevolent steps as sporadic, and essentially individual and separated movements, that tend to build up district organisations sensitive to local needs and adapted to meet these needs. The difference between English and American motives and plans is well brought out in the last chapter, in which is discussed the relative advantages of legislation or evolution, or of voluntary or compulsive development. This chapter is worth study from the psychological as from the industrial point of view. The American system was conceived in the interests of individual industries. It does not recognise the organisation either of employers or of labour as portion of the proposed organisation. The English view is based on such an organisation, so that on the one hand the voluntary system is seen in operation, on the other, a movement in the direction of authoritative organisation, though falling short of statutory authority.

BOOKS RECEIVED.

A Text Book on Heat and Heat Engines. Vol. II. By ANDREW JAMIESON, M.Inst.C.E. Re-written by EWART S. ANDREWS, B.Sc. Eighteenth edition. London: Chas. Griffin and Co. [Price 8s. 6d. net.]

Highland and Agricultural Society of Scotland. Demonstration of Farm Tractors and Tractor Implements at Fordel, Dalkeith, Midlothian, October, 1922. Edinburgh and London: Wm. Blackwood and Sons.

United States Geological Survey. Bulletin No. 736—F. *Possibility of Finding Oil in Laccolithic Domes, South of the Little Rocky Mountains, Montana.* By A. J. COLLIER and S. H. CATHCART. Professional Paper No. 131—B. *A Section of the Paleozoic Formations of the Grand Canyon at the Bass Trail.* By L. F. NOBLE. Washington: Government Printing Office.

United States Geological Survey. Water Supply Paper No. 482. *Surface Water Supply of the United States,* 1918. Part XII. *North Pacific Slope Drainage Basins.* (A.) *Pacific Basins in Washington and Upper Columbia River Basin.* NATHAN C. GROVER, Chief Hydraulic Engineer. [Price 15 cents.] No. 490—C. *Routes and Desert Watering-Places in the Lower Gila Region, Arizona.* By CLYDE P. ROSS. Washington: Government Printing Office.

Statique Cinématique. By ROBERT d'ADHEMAR. Paris: Gauthier Villars et Cie. [Price 16 francs.]

United States Bureau of Standards. Technological Paper No. 224. *Rate of Exhaustion of a Closed Tank by a Reciprocating Air Pump.* By EDGAR BUCKINGHAM. Washington: Government Printing Office. [Price 5 cents.]

United States Bureau of Mines. Bulletin No. 210. *Oil Shale, An Historical, Technical and Economic Study.* By MARTIN J. GAVIN. Washington: Government Printing Office.

Aeronautical Research Committee. Reports and Memoranda. No. 809. *The Determination of Rotary Derivatives.* By E. F. RELF, A.R.C.Sc., and others. *With an Appendix on Approximate Formulæ for Rotary Derivatives.* By H. GLAUERT. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 10d., post free.]

Tables Annuelles de Constantes et Données Numériques Art de L'Ingénieur et Métallurgie. Résistance des Matériaux et Donnees Numériques Diverses. Vol. IV., 1913, 1914, 1915, 1916. Paris: Gauthier-Villars et Cie. [Price 40 francs.]

THE WILBUR WRIGHT MEMORIAL LECTURE.—The Royal Aeronautical Society announces that the eleventh annual Wilbur Wright Memorial Lecture will be read this year by Dr. Joseph S. Ames, director of the Physical Laboratory, the John Hopkins University, Baltimore, Md., in the Theatre of the Royal Society of Arts, 18, John-street Adelphi, London, W.C. 2, on Thursday, May 31, at 5.30 p.m. The subject of the lecture will be "The Relation between Aeronautical Research and Aircraft Design." Tickets may be obtained from the Offices of the Society, 7, Albemarle-street, London, W. 1.

LOUGHBOROUGH COLLEGE.—Presentation day at Loughborough College was held on the 10th inst., when Mr. J. F. Driver, head of the department of electrical engineering at the college, was presented with the College Diploma *Honoris Causa.* In all, some 230 students were presented for the College Diploma, of which 22 were presented for first-class honours and 74 for second-class honours, the students were from the various departments of the college—mechanical and civil engineering, electrical engineering, automobile engineering and commerce and economics. The congregation was addressed by Sir Montague Barlow, the Minister of Labour, while a report on the work of the college was presented by Mr. H. Schofield, the principal. Mr. Schofield dealt with the remarkable growth of the Institution and pointed out that the number of diploma courses grew from 7 in September, 1918, to 574 in September, 1921. By September, 1922, the number had fallen to 390. This decrease is due to the completion of their course by a large number of the ex-service officers who were trained at the college. The supply of private students is, however, being well maintained and a minimum of 250 full-time diploma students is being aimed at.

THE WADE MODEL-MAKERS' LATHE.

CONSTRUCTED BY C. A. V. SMALL TOOLS, LIMITED, ENGINEERS, HOVE.

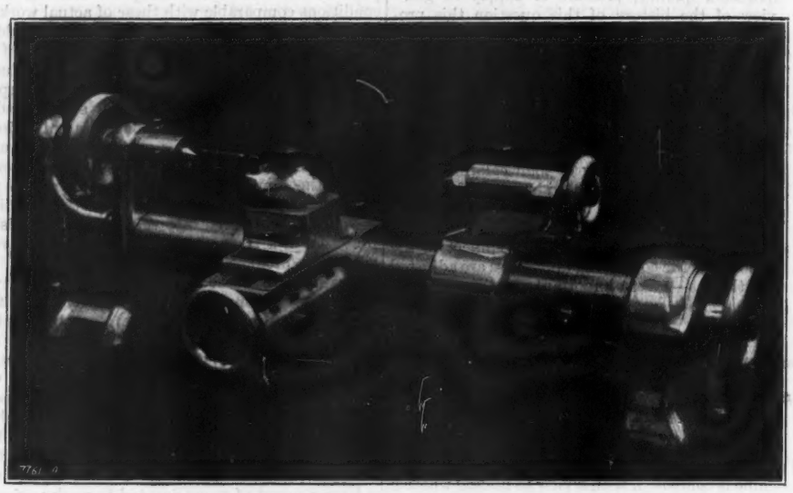
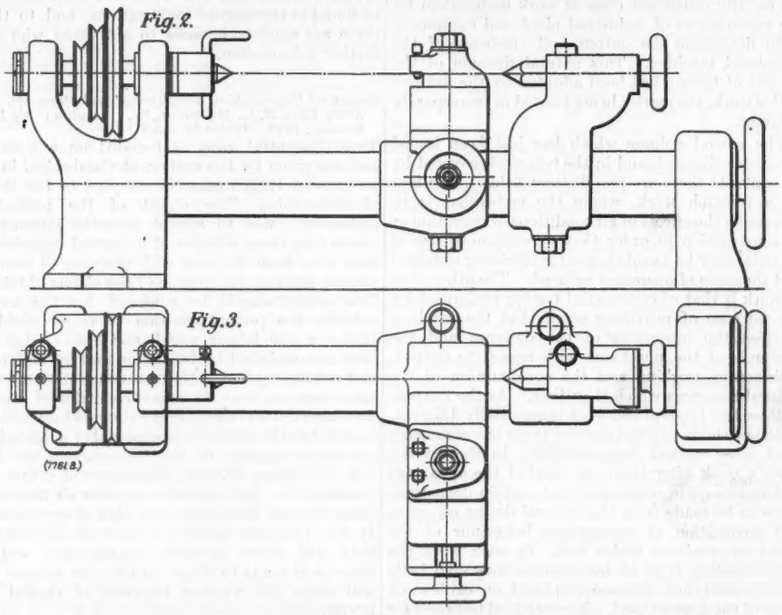


FIG. 1.



THE lathe, as the most comprehensive and adaptable of all machine tools, is the mainstay of the mechanical amateur or model-maker, for the possession of a suitable lathe with the necessary attachments enables him to dispense with the specialised machines for boring, drilling, milling, sawing, slot-drilling, grinding, &c., which constitute so much of the equipment of an ordinary engineering workshop. The ingenuity and mechanical skill required to utilise the lathe for such purposes are a further attraction to the amateur, and it is not therefore surprising that the acquirement of a lathe is one of the first ambitions of the mechanical enthusiast. Frequently, however, the purse of the latter is not deep enough to permit him to purchase the beautiful, but comparatively costly tools, built specially for amateurs, so to meet the case of those whose ambitions have to be limited by their means Messrs. C. A. V. Small Tools, Limited, of 181, Queen Victoria-street, London, E.C. 4, have recently put on the market at an exceptionally low price, the model-makers' lathe illustrated in Figs. 1 to 3, on this page.

This lathe will turn articles up to 4 in. diameter and 12 in. in length. The bed consists of a piece of steel tubing accurately ground externally to form a guide for the slide rest and the poppet head. These are prevented from rotating round the bed by engagement with a slot along the underside of the latter. The longitudinal traverse of the saddle is effected by means of a lead screw which runs through the centre of the bed and is operated by a hand wheel at the end. The saddle can traverse the full length of the bed, except, of course in so far as its travel is limited by the position of the poppet-head. Cross-traverse is effected by means of a slide on the saddle, as shown. The lathe, complete as illustrated, is sold at the remarkably low price of 50*s.*, and the experience of its makers as manufacturers of small precision tools and instruments is sufficient indication that it is equal to its duties in respect both of workmanship and design. The company supply face plates, driving dogs, wood-centres and other fittings suitable for the lathe, and they also furnish treadle motion, electric motors, belting, &c., according to the requirements of purchasers. The lathe is entirely of British design and manufacture, being produced at the works of the C. A. V. Small Tools, Limited, at Hove, Sussex.

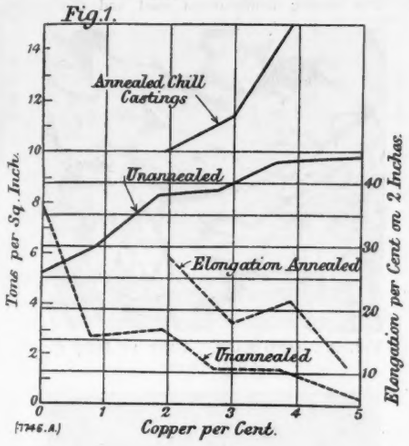
ALL-RUSSIAN AGRICULTURAL EXHIBITION.—The Russian Trade Delegation, of Soviet House, 49, Moorgate, London, E.C. 2, have issued a publication explaining the conditions applying to the participation of foreign firms in the exhibition which it is proposed to hold in Moscow from August 15 to October 1, this year. The privileges granted to Russian exhibitors have been extended to all, and preferential treatment in the transport of exhibits is promised by the Soviet Republic.

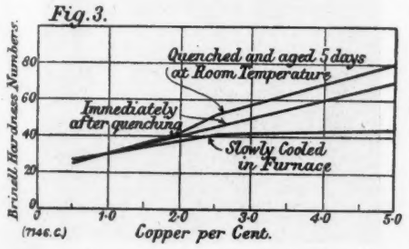
THE HEAT-TREATMENT AND MECHANICAL PROPERTIES OF ALLOYS OF ALUMINIUM WITH SMALL PERCENTAGES OF COPPER.*

By D. HANSON, D.Sc., Member, and MARIE L. V. GAYLER, M.Sc., Member. (From the National Physical Laboratory.)

THIS paper forms part of a research carried out for the Engineering Research Co-ordinating Board, Aeronautics Research Committee (Materials and Chemistry Sub-Committee), who have granted permission for the present publication. The research constitutes a continuation of the systematic study of aluminium alloys, which has long been in progress in the Metallurgy Department, National Physical Laboratory, under the direction of Dr. W. Rosenhain, F.R.S.

Introduction.—Recent work† has shown that aluminium will hold 5 per cent. of copper in solid solution at a temperature of 540 deg. C. and that this amount decreases to about 3 per cent. at 20 deg. C. Study of the constitution of these alloys has proved that this amount of copper can only be brought into solid solution by prolonged annealing, and that generally, in the production of copper-aluminium castings, free $CuAl_2$ is found in an alloy whose copper content is as low as 2 per cent. Annealing at a temperature between 450 deg. C. and 520 deg. C. for three days causes a marked increase both in the tensile strength and the elongation of chill-cast bars containing 2 per cent., 3 per cent., 4 per cent., and 4·5 per cent. of copper, as compared with bars which have not been annealed; these results, shown diagrammatically in Fig. 1, reproduced by permission of the Institution of Mechanical Engineers, indicate very clearly that considerable improvement in the mechanical properties of copper-aluminium alloys can be obtained by the heat-treatment of castings.





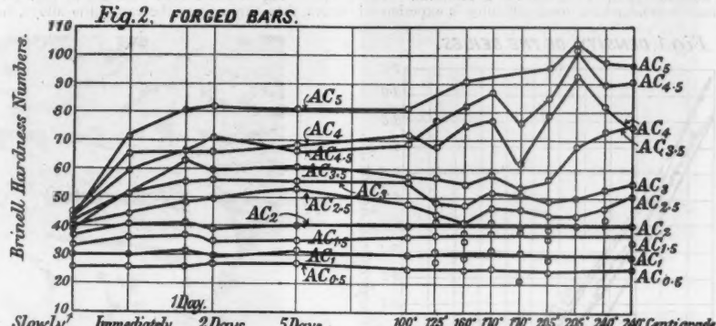
It is known that, in certain alloys in which there is a marked difference in the solid solubility of a second phase at high and low temperature, considerable improvement in the mechanical properties can be obtained by suitable heat-treatment, which usually consists in quenching from a temperature at which the solubility is greatest. Certain alloys, particularly those of aluminium, gradually harden if kept at normal temperature after such quenching; in some cases the hardening is still greater if they are reheated to temperatures slightly higher than the normal. In the present instance, treatment of this character has been applied to a series of alloys containing up to 5 per cent. of copper, and the results are described in this paper.

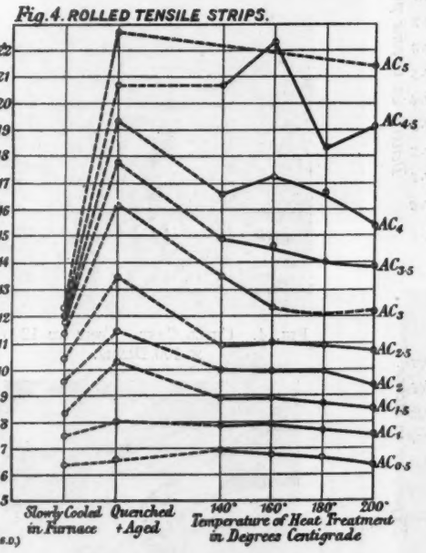
Alloys were made up from the purest aluminium available, containing 0·19 per cent. of silicon and 0·19 per cent. of iron, while the copper was added in the form of copper-aluminium alloy containing 45 per cent. of copper.

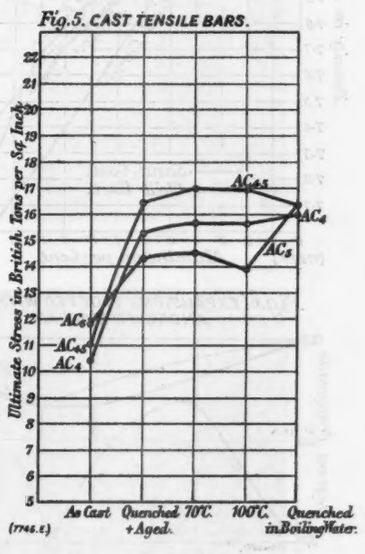
Tensile Tests and Hardness Measurements on Worked Material.—A series of alloys, whose copper content varied from 0·5 per cent. to 5 per cent. in steps of 0·5 per cent., was made up and cast into 1-in. chill moulds. The castings were flattened by forging to $\frac{3}{4}$ in. at a temperature of 450 deg. C. and subsequently rolled at the same temperature to $\frac{1}{10}$ in. thickness.

Brinell hardness measurements were made on other samples of these alloys, castings of which had been forged, at 450 deg. C., from 1 in. diameter to $\frac{3}{4}$ in. thick. The forgings were prepared for hardness measurements and were then heated for 1 hour at 500 deg. C. One series was left to cool slowly with the furnace, while another series was quenched in water and allowed to age at room temperature. Brinell impressions were made immediately after quenching and at various time intervals. The bars were then further heat-treated for 1 hour at temperatures of 100 deg., 125 deg., 160 deg., 170 deg., 200 deg., and 240 deg. C.

The hardness numbers obtained are embodied in Fig. 2. The results are of great interest and show that alloys containing less than 2 per cent. of copper do not change, while alloys with higher percentages increase in hardness as a result of this treatment, the increase being greater the higher the copper content. This increase is largely due to the retention of the copper in solution and only a small portion is due to spontaneous age-hardening at room temperature. This is indicated in Fig. 3, produced by permission of the Institution of Mechanical Engineers, which shows the results plotted in a different manner. The increase in hardness immediately after quenching is due to the retention of copper in solid solution; the further increase on storing at room temperature is due to the age-hardening of this supersaturated solid solution.







Further heat-treatment of these age-hardened bars, by consecutive heatings for 1 hour at each of the temperatures indicated in Fig. 2, causes an increase in hardness, except that the second heat-treatment at 170 deg. C. softened some of the alloys. A further heat-treatment at 205 deg. C., however, causes the alloys to harden again; at 240 deg. C. alloys containing 4 per cent. copper and over begin to soften, but those containing 3·5 per cent. copper and less become still harder. (See Fig. 2.)

Test-pieces were cut from the rolled strip, and were annealed for 1 hour at 500 deg. C. One set of bars was then left to cool slowly with the furnace, while another was quenched from that temperature into water and allowed to age-harden for five days at room temperature. Similar batches of test pieces were quenched and aged as above, and then further heat-treated at temperatures of 200 deg., 170 deg., 160 deg. and 140 deg. C.

The results of the experiments are embodied diagrammatically in Fig. 4. From the diagram it will be seen that the tensile strength of these alloys is markedly increased as a result of quenching followed by ageing at room temperature; in the case of an alloy containing 5 per cent. of copper, the strength is increased by nearly 100 per cent. Alloys containing 2 per cent. copper and less show little or no age-hardening, whereas the tensile strength of quenched alloys containing 2·5 per cent. copper and over increases rapidly with the copper content. Further consecutive heatings to temperatures of 140 deg., 160 deg., 170 deg. and 200 deg. C., cause a fall in tensile strength.

Attention may here be drawn to the actual tensile strengths obtained. In the slowly-cooled alloys the maximum strength is only about 12 tons per square inch, with about 30 per cent. elongation. In the heat-treated alloys, tensile strengths of practically 23 tons per square inch with an elongation of 25 per cent. have been obtained. Not only is the increase great, but the actual tensile strength is high for a rolled aluminium alloy.

Tensile Tests on Chill-Cast Bars.—Three alloys, containing 4 per cent., 4·5 per cent. and 5 per cent. copper were cast into chill moulds, after which they were turned down to test-pieces of the standard size (0·564 in. diameter).

The bars were annealed for 24 hours at 500 deg. C., quenched in ice water, and aged for six days at room temperature. Two sets of bars, which had been similarly treated, were then further heat-treated for 1 hour at 100 deg. C., and 1¼ hours at 70 deg. C., respectively. A third set of bars was heated to 500 deg. C. for 1 hour, quenched in boiling water, and held at 100 deg.C. for 1 hour.

The ultimate tensile strengths and elongations of the bars (in duplicate) are shown diagrammatically in Fig. 5. It will be seen that in the case of the alloy containing 4·5 per cent. copper, the tensile strength can be raised from 11 tons per square inch in the "as cast" state, to about 17 tons by suitable heat-treatment, while at the same time the elongation is increased from 14 per cent. to 18 to 25 per cent. on 2 in. An elongation of over 20 per cent. in an aluminium alloy casting possessing a tensile strength of 17 tons per square inch is extremely high. A tensile strength of this order in a chill-cast, heat-treated bar of light aluminium alloy is remarkable, and has hitherto been exceeded only in the case of the alloy Y, a much more complex material which, however, attains over 20 tons per square inch.

Conclusions.—(1) Copper-aluminium alloys containing 0 per cent. to 2 per cent. of copper are not appreciably affected by quenching from 500 deg. C. and subsequent ageing.

(2) Alloys containing 2·5 per cent. to 5 per cent. of

* Abstract of a paper read at a meeting of the Institute of Metals on Thursday, March 8.

† W. Rosenhain, S. L. Archbutt, D. Hanson, "Some Alloys of Aluminium" (Light Alloys). Eleventh Report to the Alloys Research Committee, Institution of Mechanical Engineers, August, 1921.

copper are profoundly affected by this form of heat-treatment. The strength of a rolled and annealed 5 per cent. alloy is increased from 12 tons per square inch to 23 tons per square inch as a result of quenching and ageing; at the same time the elongation is high.

(3) Further treatment of quenched and age-hardened material, at a temperature higher than the normal, does not improve the tensile strength, but in some cases the Brinell hardness is increased.

In conclusion, the authors wish to express their indebtedness to Mr. P. Ward, B.Sc., and Miss A. M. O'Hea, who have analysed all the alloys used, and also to Mr. S. A. E. Wells, who has helped them in the casting of the alloys, and to Dr. W. Rosenhain, F.R.S., for the encouraging interest he has taken in this work.

SOME PROPERTIES OF THE COPPER-RICH ALUMINIUM-COPPER ALLOYS.*

By R. C. READER, M.Sc., Student Member, Birmingham.

THE present research deals only with such alloys as contain not more than 11 per cent. of aluminium. This is the limit beyond which great difficulty is experienced in obtaining sound castings. The object of the research was to investigate certain properties in relation to which doubt existed or further information appeared desirable. The general outline of the experimental work undertaken is as follows: (1) density, (2) volume changes during and after solidification, (3) self-annealing properties, (4) effect of heat-treatment on the 10 per cent. alloy.

Fig. 1. DENSITY OF THE SERIES.

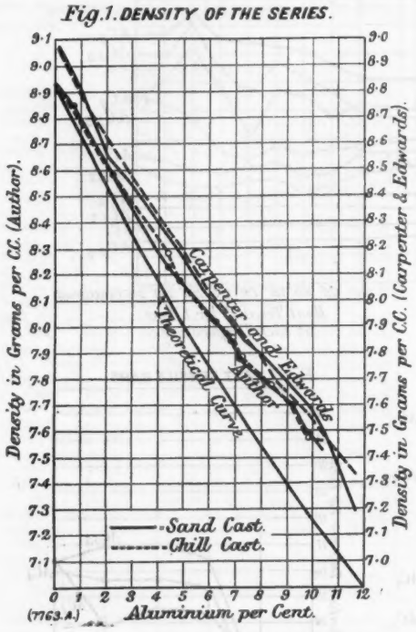
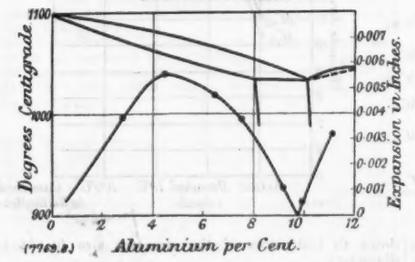


Fig. 6. EXPANSIONS PLOTTED WITH ANDREW'S DIAGRAM.



Density of the Alloys.—Density determinations were made for the portion of the series from 0 per cent. to 11 per cent. of aluminium, both sand and chill cast specimens being examined. The castings from which the specimens were taken were cylindrical in shape, 8 in. long and 1 in. in diameter, while the specimens on which the determinations were made were of relatively considerable size, being 6 in. long by $\frac{3}{4}$ in. diameter. This size was adopted in order that Arnold alternating stress tests could be made on the same specimens. This was not merely a convenience, but it has the advantage of employing a larger sample than is usual for the density tests.

In the determinations the usual method of weighing in air and water, as described by Bamford,† was employed. The formula used in the calculations was:—

$$D = \frac{W}{W - W_1}(G - \lambda) + \lambda.$$

where D = density required.
W = weight of the specimen in air.
W_1 = weight of the specimen in water.
G = density of the water at time of experiment.
λ = density of the air at time of experiment.

and calculations were made by means of 5-figure logarithm tables.

As the density specimens, on account of their length, included practically the whole length of the casting, the probability of errors due to the selection of a locally unsound specimen was as far as possible eliminated. Hence the figures obtained give the average for the whole casting rather than the maximum obtainable.

The experimental values are plotted in Fig. 1, together with results obtained by Carpenter and Edwards,* which are inserted for comparison.

Referring to the curves obtained in Fig. 1 it will be noted that throughout the range the alloys, both sand and chill, are more dense than would be expected from the calculated theoretical curve.

The formula used in the calculation of the theoretical density curve was:

$$D = \frac{100\,D\,d}{W\,d + w\,D}$$

where W = per cent. of element of density D,
and w = per cent. of element of density d.

The density of pure copper was taken as 8·93 grammes per c.c., and pure aluminium as 2·70.

An interesting feature of the curves is that a check is provided for the range 8 per cent. to 11 per cent. of aluminium, in which Carpenter and Edwards found the sand-cast specimens to be more dense than the chill. This rather unusual state of affairs is explained by Professor Turner in his May lecture to the Institute of Metals, 1921.

The compound Cu_3Al is dissociated at a high temperature, with an increase of volume, giving a lower density, and in the case of a chill-cast bar, owing to the quick rate of cooling, insufficient time is allowed for the compound to reform. In the case of a sand-cast bar, however, where the rate of cooling is much slower, time is given for some of the compound to reform, with a decrease of volume and an increase in density.

Influence of Casting Temperature on the Density of 10 per Cent. Aluminium-Copper Alloy.—The casting of specimens for this experiment was regulated by the use of a base-metal thermocouple used without a sheath, the temperature being taken immediately before pouring.

The sand-cast bars were all cast in the same moulding-box to ensure uniformity of moisture content of the sand and so prevent any irregularity in chilling. Four bars were cast in the one box, and they were sufficiently far apart to prevent one bar supplying heat to the others.

The casting temperatures used and the densities obtained, given in the paper, showed that the casting temperature has a slight but distinct effect upon the density, the higher the casting temperature the lower the density. Hence, in order to obtain the soundest possible alloy a low casting temperature should be employed.

The results are in conformity with the statement of Carpenter and Edwards,* that the nearer the alloy could be poured to insipient solidification consistent with thorough fluidity the better.

Photomicrographs of sand-cast specimens are shown in Figs. 2 and 3, and chill-casts in Figs. 4 and 5.

Effect of Rate of Cooling on the Density of 10 per Cent. Aluminium-Copper Alloy.—In order to investigate the effects of rate of cooling on the alloys it was decided

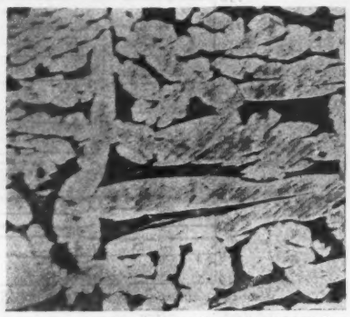


FIG. 2. SAND CAST. CAST AT 1220° C. × 100 DIAMS.

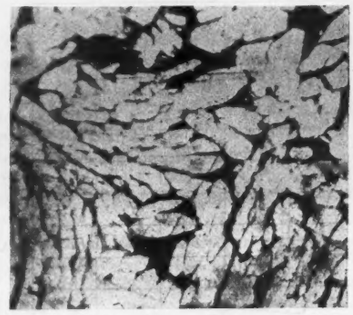


FIG. 3. SAND CAST. CAST AT 1092° C. × 100 DIAMS.

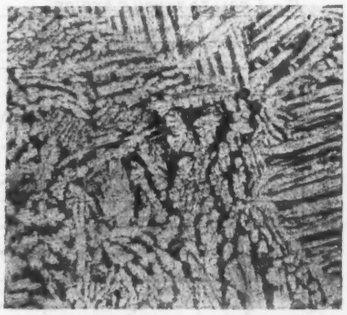


FIG. 4. CHILL CAST. CAST AT 1200° C. × 100 DIAMS.

FIG. 5. CHILL CAST. CAST AT 1050° C. × 100 DIAMS.

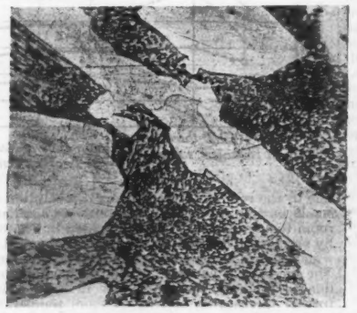


FIG. 7. SELF-ANNEALED. × 200 DIAMS.

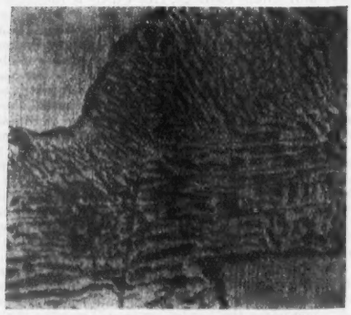


FIG. 8. SELF-ANNEALED. × 600 DIAMS.

ALL ETCHED WITH FERRIC CHLORIDE.

* Abstract of a paper read at a meeting of the Institute of Metals on Thursday, March 8.

† T. G. Bamford, *Journal of the Institute of Metals*, No. 2, 1921, vol. xxvi, page 161.

* "Eighth Report to the Alloys Research Committee of the Institution of Mechanical Engineers, 1907," page 111.

* *Loc. cit., page* 327.

to cast a number of bars of different diameters, but all cast from the same pot of metal and at the same temperature.

Accordingly, a series of bars of different cross-sectional areas was cast by a "hen-and-chickens" device, using a central runner, from which all the bars were fed. By this means bars of ¼ in., ½ in., 1 in. and 1¼ in. diameter were cast.

The central runner down which the metal was poured was not utilised.

The density figures showed that the larger the bar, and therefore the slower the cooling, the lower the density.

Specimens from these bars were examined microscopically, and the variations in structure found were similar to Figs. 2 and 3, denoting structures of sand-cast bars, cast at different temperatures.

That the slower rate of cooling should lower the density is what might be expected, since it has already been shown that higher casting temperature gave the lower density, because a metal or alloy cast at a high temperature will have a greater superheat than one cast at a lower temperature, and will therefore cool more slowly.

Volume Changes of the Series.—The term "volume changes" is here taken to refer to the variations in volume which occur when a molten metal or alloy solidifies, and includes any changes of volume which may occur in the solidified metal during the subsequent process of cooling.

That slight variations in volume do occur in a solidified and cooling alloy have been demonstrated by the differences in density that can be obtained in the same alloy by different rates of cooling.

The instrument used in the experiments was the original one employed by Turner and Murray.*

Briefly, the method of working was to cast the molten alloy into a prepared dry T-shaped mould, and extensometer and pyrometer readings are taken every 5 seconds. The experiments were continued until the specimen had cooled down to 400 deg. to 500 deg. C. The figures so obtained were plotted, time as abscissæ, with temperature and extensometer readings as ordinates.

The expansions recorded were given in the paper.

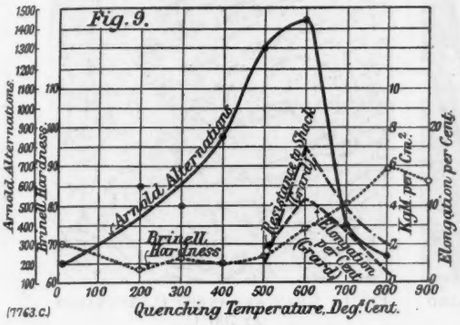
According to Murray,† expansions taking place during solidification with slow cooling, as in a sand mould, are proportional to the distance between the solidus and liquidus curves. It will be seen from Fig. 6, where the expansions recorded are plotted together with the necessary part of Andrew's‡ diagram, the figures obtained support Murray's view.

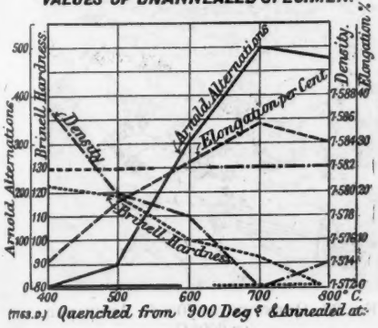
It was found that alloys with more than 10 per cent. of aluminium, which are difficult to obtain sound, give expansions during solidification which are much larger than would be expected from the equilibrium diagram. It was observed that general contraction starts as soon as the cooling arrest, due to solidification, is over. This shows, therefore, that the expansions occur only within the solidifying range. Hence, where the solidus and liquidus meet there will be no expansion.

No heat evolutions or signs of volume changes are recorded in any of the alloys tested after solidification was completed, the form of apparatus used not being sufficiently sensitive to detect the various phase changes. Changes in the solid have been investigated by Bresco,* who, by using a very delicate recording device, was able to detect volume changes at 530 deg. to 560 deg. C. on heating and 540 deg. to 500 deg. C. on cooling.

To summarise, it may be stated that the volume changes which occur during solidification are proportional to the crystalline interval, and that by the use of a very sensitive recording device dilations can be observed correspondingly with various phase changes.

Self-Annealing Properties of 10 per Cent. Aluminium-Copper Alloy.—The term "self-annealing" of aluminium-copper alloys is used to refer to the harmful results which occur to this alloy when it is allowed to cool slowly. This self-annealing only takes place in alloys containing more than 8 per cent. of aluminium—that is, when the β phase makes its appearance.





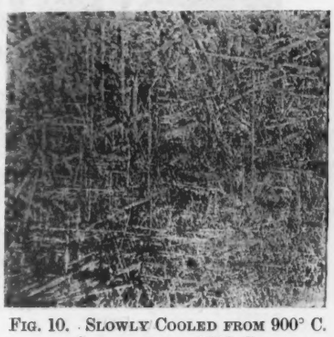


FIG. 10. SLOWLY COOLED FROM 900° C. QUENCHED AT 700° C.

FIG. 11. SLOWLY COOLED FROM 900° C. QUENCHED AT 500° C.

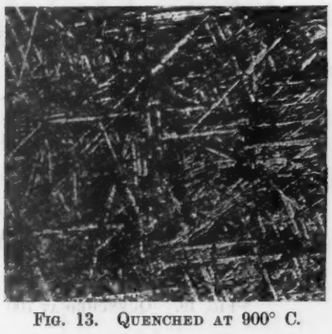


FIG. 13. QUENCHED AT 900° C.

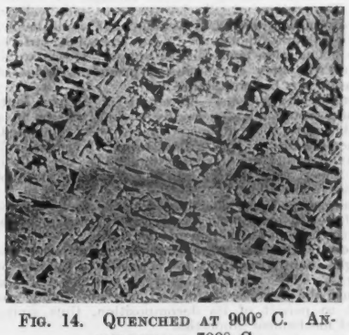


FIG. 14. QUENCHED AT 900° C. ANNEALED AT 700° C.

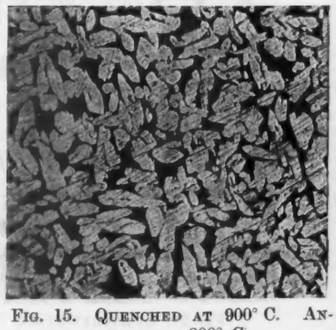


FIG. 15. QUENCHED AT 900° C. ANNEALED AT 800° C.

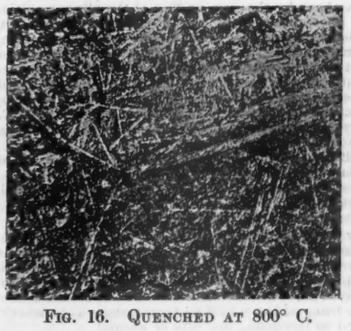


FIG. 16. QUENCHED AT 800° C.

× 100 DIAMS.—ALL ETCHED WITH FERRIC CHLORIDE.

The following facts are of interest as showing the various limits within which this self-annealing can take place:

1. With more than 92 per cent. of copper the alloy is not affected by rate of cooling, nor does it readily lend itself to improvement by heat-treatment. This is, perhaps, what might be expected, as alloys with 92 per cent. of copper, and over, are within the range of the α solid solution.

2. The ductility of cast alloys decreases from an elongation of about 70 per cent. on 2 in. for the 7 per cent. aluminium alloy to about 20 per cent. for the 10 per cent. alloy. Alloys within this range are very sensitive to heat-treatment.

Hence it may be inferred that the self-annealing is due to some change taking place within the β solution.

In order to obtain comparative figures for the deterioration of the 10 per cent. alloy by variations in the rates of cooling, four bars were cast by means of a "hen-and-chickens" bottom-pouring device. The bars were ¼ in., ½ in., 1 in. and 1¼ in. in diameter and 8 in. long. The central runner down which the metal was poured was not utilised. As all bars were cast at once, the casting temperature for each was identical. The largest bar may be taken as having cooled the slowest, the 1-in. bar the next, and so on. These bars, when tested in an Arnold alternating stress machine, were found to be practically identical. The micro-structures of all were the usual α and β structure of normal 10 per cent. aluminium-copper alloys.

As a 1¼ in. bar cast in sand was not subject to self-annealing, a much larger bar was cast. This was 8 in. long and 4·5 in. diameter. To illustrate the rate of cooling of this casting, it was too hot to hold 18 hours after pouring, this being due to the fact that the box was completely covered with dry moulding sand as soon as the casting operation was completed. An Arnold test-piece removed from the specimen broke at the fourth bend. Another bar, roughly tested by striking with a hammer when held in a vice, broke at the third blow, while a normal bar tested alongside had not broken at 20. The fractured surfaces of the above self-annealed bars showed a distinct greyish colouration.

An examination of the microstructure of the self-annealed casting revealed a structure entirely different from the normal α + β, and this is shown in Figs. 7 and 8 at magnifications of 200 and 600 respectively. These photographs show that none of the original β constituent remains, the whole having decomposed into α + δ. When it is stated that an alloy containing 16 per cent. of aluminium, and so consisting of pure δ, is so brittle that it breaks when dropped on the floor, and that it can be readily pulverised in a mortar and pestle, the serious results which occur to a slowly-cooled alloy will be appreciated.

When β decomposes at 570 deg. C., it splits up into α, containing 9 per cent. of aluminium, and δ, containing 16 per cent. of aluminium. This brittle δ is present in

* Turner and Murray, *Journal of the Institute of Metals*, No. 2, 1919, vol. ii, page 103.

† *Ibid.*, page 116.

‡ J. H. Andrew, *Journal of the Institute of Metals*, No. 1, 1915, vol. xiii, page 250.

* P. Bresco, "Dilatometric Study of Alloys," *Annales de Physique*, 1920, vol. xiv, page 66.

a course state throughout the mass of the metal, and it is evident, therefore, that it must provide planes of excessive weakness, and planes which have little power of resisting shock, thus rendering the alloy exceedingly brittle.

From the foregoing remarks it will be seen that on allowing an aluminium-bronze alloy to cool slowly, if the cooling be sufficiently slow to permit the whole of the 570 deg. C. change to be completed, the alloy will be brittle. If, however, the cooling be sufficiently fast to prevent a part of the change, the alloy will possess good mechanical qualities, while if quenched immediately above the critical range the metal will have a high shock resistance and percentage elongation.

In order to verify these conclusions, and to find at what point self-annealing commences in practice the following experiments were made. A series of bars (9·50 per cent. aluminium) were heated in a gas muffle to 900 deg. C., allowed to remain there for half an hour, when one bar was withdrawn from the muffle and quenched in water. The remaining bars were slowly cooled in the muffle, and one of the bars withdrawn and quenched every 100 deg. C. down. The approximate time of cooling through each 100 deg. C. was 20 minutes.

The results of the Arnold tests and Brinell hardness tests on the bars are plotted on Fig. 9, together with curves denoting resistance to shock and percentage elongation as found by Grard.*

It will be seen from Fig. 9 that all three curves show the sudden change in mechanical properties at 600 deg. C., and that the alloy does not give maximum values on either side of this point. This can be accounted for by an inspection of the photomicrographs, Figs. 10 and 11. The alloys quenched at 900 deg., 800 deg., and to a lesser degree alloys quenched at 700 deg. C., have an acicular structure with which brittleness is always associated. Below 600 deg. C. the reduction in mechanical properties is due to the self-annealing, when the β decomposes to ductile α and brittle δ.

An examination of the fractured bars shows that bars quenched at 700 deg. C., and above, break between the crystal grains, while those quenched at 600 deg. C. 500 deg., and 400 deg. C. show an uneven but fine structure, fracture having occurred through the crystal grains. The colour of all the fractures was yellow. In the case of bars quenched at 300 deg. C., and below, a greyish colouration is seen in the fractured surface, and this colouration lends further support to the statement that the grey δ constituent provides planes of weakness for any bar containing it.

Annealing Experiments.—A casting of 10 per cent. aluminium-copper alloy, normally cooled, will be in a metastable state, the β inversion having been prevented. An annealing below the critical range, however, will result in the restoration of equilibrium and the decomposition of the β into $\alpha + \delta$, bringing about a state of brittleness in the alloy.

Annealings made for 20 minutes at the temperatures stated, followed by cooling in air, give figures in agreement with those of Carpenter and Edwards.

The results show the great deterioration of properties so brought about when this alloy is heated to 400 deg. or 500 deg. C. The alloy annealed at 800 deg. C. was raised into the β range again, and the air-cooling was too fast to permit of its decomposition, thus giving improved mechanical properties.

Summary of the Self-Annealing Experiments and Results.—Self-annealing in aluminium-copper alloys is brought about by the slow cooling of the alloy, resulting in the decomposition of the β constituent into its components α and δ. This latter component, being exceedingly brittle, imparts very disadvantageous properties to any alloy containing it. If the alloy be cooled sufficiently fast to prevent a part of the change it will possess satisfactory mechanical qualities, while if the alloy be quenched above the critical range (at 600 deg. C., as shown in Fig. 9) a high shock resistance and percentage elongation will result.

If self-annealing sets in during the cooling of an aluminium copper casting, the useful mechanical properties of the alloy can be largely restored by a suitable heat-treatment.

The best means of preventing self-annealing are :—

1. By modifying the composition—that is, keeping the aluminium content in the neighbourhood of 9·5 per cent. to 10 per cent.—so that in the event of any self-annealing taking place less harmful results will occur than if the 10 per cent. mark be exceeded.

2. By using as low a casting temperature as is practicable, and so increasing the rate of cooling.

3. Spraying the moulds (in the case of sand-castings) as soon as the metal has solidified, thus producing a chilling effect and increased rate of cooling.

4. Removing the metal from the mould as soon as it has solidified and allowing to cool in the air.

Castings in aluminium-copper should be cast with small lugs attached, so that these lugs may be removed and examined microscopically. By this means evidences of self-annealing will be revealed. The existence of self-annealing can also be detected in a lesser degree by an examination of a fractured surface, as, when it has occurred, a greyish colouration is observed, while in the case of a normally cooled bar or suitably heat-treated specimen, a beautiful yellow colouration is seen.

Heat-Treatment of 10 per Cent. Aluminium-Copper Alloy.—The heat-treatment experiments were carried out not only to find the effects on the mechanical properties, as denoted by the Arnold test, and the hardness, but also on the density.

It has been shown by Carpenter and Edwards, and others, that brittleness first of all makes its appearance when the alloy contains over 8 per cent. of aluminium. It is approximately at this composition that the density of the sand-cast specimens has a higher value than those of the chill-cast. It was therefore anticipated that the heat-treatment which would be the ideal for the removal of brittleness would also be the one which lowered the density of the sand-cast specimens to below that of the chill.

(The results of the various heat-treatments were given in the paper.)

The values obtained for annealed specimens after quenching from 900 deg. C. are illustrated in Fig. 12, together with curves denoting fluctuations of elongation percentage caused by similar heat-treatment as found by Grard.

All the figures recorded are not reproduced in graphs, as the graphs would be very small, due to the small range of temperature used, and because they impart no useful properties to the alloy, except perhaps in the case of the unannealed alloy after quenching from 600 deg. C. Specimens quenched at this temperature possess maximum ductility of any unannealed alloy after quenching from the various temperatures. This is also borne out by the curve in Fig. 9.

As before stated, it was hoped by these experiments to show that when the density of the specimens was reduced within the region 8 per cent. to 11 per cent. of aluminium, an improvement in mechanical properties would result. This is shown, in general, to be so. The lowest density, however, does not yield maximum ductility, and so an intermediate density may be concluded to give the best results.

The differences in density recorded on the heat-treated specimens are very small indeed—in fact, they are only just outside what may be taken to be the limit of experimental error, namely, 0·01 absolute value.

Density determinations have been made by Riche on heat-treated specimens, who obtained the following results :—

Condition.				Density.	
As cast	...	...	...	7·705	7·704
Quenched	...	...	...	7·706	7·704
Annealed	...	...	...	7·706	7·705

Photomicrographs of some of the heat-treatments are shown in Figs. 13 to 22. In Figs. 13, 14 and 15, denoting the specimens quenched from 900 deg. C. and annealed at various temperatures, it will be seen that the unannealed specimen is wholly acicular, and therefore little ductility can be expected of it. Upon annealing, this acicular structure is removed with the gradual separation of the α constituent. After annealing at 700 deg. C. there is a fine structure with the β very finely divided throughout, and none of the original structure remains. The complete removal of the acicular structure, and the even distribution of the β in a fine state throughout the alloy, account for the increased ductility obtained by annealing.

On account of the marked difference between the structure of the unannealed alloy and the one annealed at 800 deg. C., differences in hardness can be expected. The hardness curve (Fig. 12) shows an almost gradual depression, due to the separation of the α constituent with ascending annealing temperatures.

The structure of the alloys annealed after quenching from 800 deg. C. are shown in Figs. 16, 17, 18. In this series also there are marked differences between the annealed and unannealed specimens, with the corresponding differences in properties.

In the 700 deg. C. series, however (Figs. 19 and 20), the structures of the annealed and unannealed specimens are very similar; consequently, the variations in properties are not so great as in the case of specimens

FIG. 17. QUENCHED AT 800° C. ANNEALED AT 500° C.

FIG. 18. QUENCHED AT 800° C. ANNEALED AT 700° C.

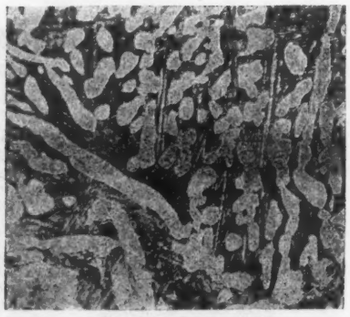


FIG. 19. QUENCHED AT 700° C.

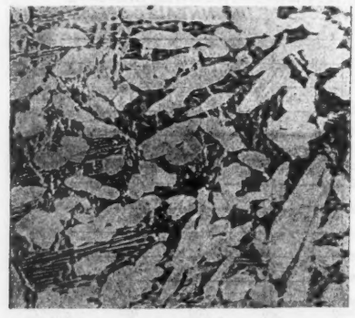


FIG. 20. QUENCHED AT 700° C. ANNEALED AT 600° C.

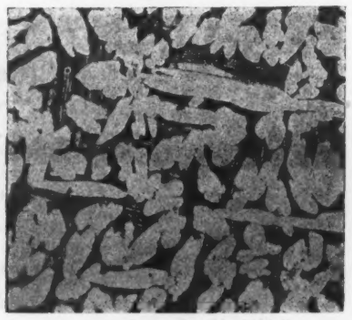


FIG. 21. QUENCHED AT 600° C.

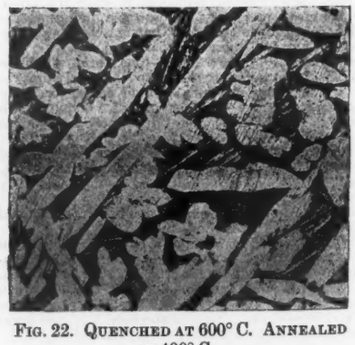


FIG. 22. QUENCHED AT 600° C. ANNEALED AT 400° C.

× 100 DIAMS. ALL ETCHED WITH FERRIC CHLORIDE.

* Grard, "Aluminium and Its Alloys," page 125. (London : Constable and Co.)

annealed after quenching from 800 deg. and 900 deg. C.

Figs. 21 and 22 illustrate the structures of alloys quenched from 600 deg. C. and annealed. In the case of the specimen annealed at 400 deg. C. (Fig. 22), the result of the annealing has been to permit a part of the β to decompose. This is in accordance with the Arnold figures, the paper showing that annealing after quenching from 600 deg. C., instead of bringing about an improvement in ductility does exactly the reverse.

It is evident that the best form of heat-treatment to bring about maximum ductility is an annealing at 700 deg. C. after quenching from 900 deg. C. By this means a very fine $\alpha + \beta$ structure, indicative of strength and ductility, is imparted to the alloy.

As the annealing at 700 deg. C., after quenching from 900 deg. C., yields the highest Arnold figure, it may be taken that this heat-treatment is the one most suitable for the removing of brittleness, and is therefore the one which should be performed on a casting which has been cooled sufficiently slowly to allow self-annealing to occur.

The time of the anneal is of great importance. In the present experiments it was 20 minutes. If the time be unduly long, sufficient time is allowed for the α grains to increase in size and the β grains to decompose, thus ruining the excellent mechanical properties which may be imparted to aluminium-copper by heat-treatment.

At the previous meeting of the Institute a more theoretical paper on the copper-rich end of the aluminium-copper alloys was presented by Mr. D. Stockdale. The present contribution may be regarded as being supplementary to Mr. Stockdale's paper. It deals more particularly with the variations in mechanical properties of the alloys caused by different methods of thermal treatments. It is hoped that the treatments employed and the results obtained are such as are likely to prove of practical value to those who are interested in non-ferrous alloys.

The author wishes to express his sincere thanks to Professor Turner, in whose laboratory the research was conducted, for his suggestion of the subject, and his interest in the work, and to Professor Desch for his carrying out of the Arnold alternating stress tests. His thanks are also due to Mr. B. Bloomer for carrying out much of the routine work, and to the Department of Scientific and Industrial Research for financial assistance.

THE PRODUCTION AND HEAT-TREATMENT OF CHILL-CASTINGS IN AN ALUMINIUM ALLOY ("Y").*

By W. ROSENHAIN, D.Sc., F.Inst.P., F.R.S., Vice-President; S. L. ARCHBUTT, F.I.C., Member; and S. A. E. WELLS, Member.

Introduction.—HEAT-TREATED chill-cast rods of the "Y"† alloy have been found, from time to time, to give tensile tests showing an ultimate stress of 21 tons per square inch, combined with an elongation of 5 per cent. to 6 per cent. on 2 in. While these tests indicated the remarkable capacity of this alloy to attain great strength after heat-treatment, their value for practical purposes was considerably reduced by the fact that such results could not be obtained with complete regularity. Without any marked difference either in the composition of the alloy, or the method of casting or heat-treatment results as low as 13·3 tons per square inch for ultimate tensile strength were obtained, so that the higher degree of strength could not be relied upon with regularity or certainty.

It appeared, therefore, desirable to investigate the causes of this variability more closely. The endeavour to eliminate this irregularity has led the authors to make a detailed study of the process of chill-casting so far as rods 1 in. diameter are concerned. The results obtained are regarded as very satisfactory, since it is now possible to prepare chill-cast rods of this alloy which regularly give values of tensile strength exceeding 20 tons per square inch, while in one remarkable instance a strength of 23 tons per square inch, combined with an elongation of 14 per cent. on 2 in., has been obtained. Not only has the result proved satisfactory in regard to this particular alloy, but it has thrown very considerable light upon the factors which influence the properties from the strength point of view of chill-castings in general. The results described in the present paper relate, it is true, merely to simple cylindrical rods 1 in. diameter and 7 in. long. None the less, the principle which has been revealed by the detailed study of such castings must be applicable to chill-castings or die-castings of any kind, whether made of this particular alloy or of other materials. The present paper may therefore be regarded not only as a study of the properties of the "Y" alloy in the form of chill-castings, but as a contribution to the detailed study of the factors governing the properties of chill and die-castings generally.

Discoloration in Fractures.—The first step in the present investigation was the careful examination of fractured tensile test-pieces of heat-treated "Y" alloy which had given unsatisfactory results. On a number of these slightly discoloured spots were visible on the fracture. It was found on careful examination that spots of this kind were invariably present in test-pieces which had given low results. In order to determine the cause of these discoloured spots, it was necessary to ascertain whether they were present in the bars in the condition as cast, or were produced by subsequent treatment. By breaking a number of bars in the "as cast" condition, it was soon found that fractures thus obtained were uniformly clean and bright, so that the discoloration was evidently not present prior to heat-treatment. It was therefore thought that possibly the discoloration might arise from cracks which had been produced during heat-treatment, either by unduly rapid heating when the bars were introduced into the molten salt bath, or by unduly severe chilling during the subsequent quenching. To test this point some bars were slowly heated from room temperature in an electric muffle furnace, and only transferred to the salt bath for completion of the heat-treatment when their temperature had reached that of the bath. Another batch of bar was left in the electric muffle furnace itself and heat-treatment completed there. When subsequently tested both sets of bars showed discoloured patches on the fractures, accompanying low test results.

It was next thought that possibly electrolytic action might occur in the fused salt bath in a manner which is known to take place in the heat-treatment of certain other alloys. In order to avoid this, the bars were held when immersed in the salt bath in a cage and wires made of the same material as the bars themselves ("Y" alloy), thus preventing the formation of any galvanic couple with the fused salt as electrolyte. The defects were, however, still found when the bars were broken.

The production of cracks during quenching of the bars after heating in the salt bath was tested by means of a series of bars which were heat-treated in the normal way, but instead of quenching from the salt bath were transferred to an electric muffle furnace standing at a temperature of 520 deg. C. The furnace with the bars in it was then allowed to cool to room temperature in about 16 hours.

Further batches of bars were heat-treated normally in the salt bath and quenched, employing less drastic media, such as fish oil at room temperature, fish oil raised to 150 deg. C., and cooling in a jet of compressed air. The last process of cooling approximately occupied 10 minutes.

It was found that low tensile results and discoloured fractures occurred with all these treatments. It may therefore be concluded that merely heating the bars, in whatever manner, is sufficient to produce discoloured patches upon the fractures. If these patches are due to cracks or cavities in the metal, it follows that such cracks or cavities must exist in the bars when first cast, and that they are not produced by subsequent treatment.

This conclusion can be further tested by ascertaining whether an oxidising atmosphere is necessary to bring about the discoloration when the bars are heated. For this purpose bars were treated in an atmosphere of hydrogen and nitrogen respectively, and broken in tension; perfectly clean bright fractures were obtained. Examination with a binocular microscope, however, showed that small cavities were present, having the characteristic feature of casting unsoundness, viz., the projection of minute dendritic crystals into the cavities. In these bars, although the discoloration of the fracture had been avoided by the absence of an oxidising atmosphere during heating, the unsoundness had not been removed, and low tensile results were still obtained. The conclusion is therefore confirmed that the discoloured patches observed on the fractures of bars as ordinarily heat-treated are due to the penetration of oxidising gases through the metal into cavities, or unsoundness existing in the cast bar.

A ready means of detecting unsoundness in chill-cast bars of the kind under examination is furnished by determining the density of the cast bar. This was rendered particularly desirable, because the surface appearance of the bars after machining into the form of test-pieces gave no indication whatever of unsoundness. Density determinations were made in the first place upon cylindrical pieces 6 in. long by 1 in. diameter cut from the 7 in. by 1 in. diameter chills. It was found, however, that when such pieces were turned down in the lathe, the apparent density of the whole piece diminished with the removal of successive layers. This result indicated that the unsoundness was located at or near the centre of the cast bar. In order, therefore, to make the density determination a better guide to the tensile strength which might be expected, the determinations were subsequently carried out on test-pieces* machined approximately to size. The correlation between density determined in this way and tensile strength is very close.

Formation of Unsound Cors.—The experience which had been obtained in the casting of bars and billets in chill moulds from other alloys indicated that the probable cause of unsoundness at the centre of a chill-cast bar lies in the formation of an unduly deep ring of radial or "chill" crystals starting from the surface of contact with the mould. Where these radial crystals are developed to an excessive extent there always seems to be a considerable tendency for the formation of cavities in the centre of the bar. Previous experience in the casting of slabs for rolling purposes serves to show that where a deep layer of chill crystals is formed there is a strong tendency for the slabs to split down the middle, while such a tendency can be avoided by diminishing the depth of this chill. The manner in which the formation of an undue depth of chill crystals could be avoided was therefore studied, and it appeared at once that the governing factor is the amount of chill which is given to the metal in immediate contact with the mould. This in turn must depend upon the heat capacity of the mould, and will be governed both by the temperature of the mould and by its mass, specific heat and thermal conductivity. With a given material of mould, and a mould temperature fixed by other considerations, the depth of chill can be influenced only by the cross-sectional area of the mould, and attention has therefore been given to determining the best ratio of cross-sectional area of mould to casting.† When a heavy cast-iron mould is used, while the outer layer of metal in contact with the mould is rapidly chilled and solidified, the rate of solidification of the liquid metal in the centre of the casting is much slower, and this shows itself by excessive "piping." Even when the rate of pouring is so controlled that a minimum amount of molten metal is at any time in the mould, this cannot entirely overcome the effect of the excessive chilling of the outer surface. Although a certain amount of improvement can be effected by the subsequent addition of molten metal during solidification ("following up"), it is not possible by this means entirely to prevent the formation of contraction cavities. A certain amount of improvement can also be effected by increasing the temperature of the mould, and this is particularly effective in the case of aluminium alloys, when the temperature of the mould can, if necessary, be raised nearly to that of the freezing point of the alloy. Too high a mould temperature, on the other hand, brings with it disadvantages nearly as serious as those (cold shuts, &c.) resulting from an unduly low mould temperature. The mould temperature, therefore, becomes fixed by a consideration of the quality of the surface produced on the casting, and the regulation of the amount of chilling can best be effected by varying the mass of the mould itself.

The cast-iron moulds which were generally used in the laboratory for the production of chill-cast bars 1 in. in

TABLE I.—CASTING TEMPERATURE 750 DEG. C. THROUGHOUT.

Melt No., &c., of Bar.	Analysis Per Cent.			Mould Temp., ° C.	Corrected Density. Grms. per c.c.		Ultimate Stress. Tons per Sq. Inch.	Condition when Tested in Tension.
	Magnesium.	Nickel.	Copper.		¾ In. Diam. Rod.	Roughed-out Test-piece.*		
				7 : 1 *Mould.*				
V 1688 (2) ..	1·49	2·03	4·04	350	—	2·754	—	
V 1639 (17) ..	1·64	1·99	4·05	350	—	2·756	16·50	Heat-treated.
V 1666 (10) ..	1·67	2·04	4·04	350	—	2·751	9·90	As cast.
V 1666 (15) ..	1·67	2·04	4·04	350	—	2·754	13·30	Heat-treated.
The above four bars are average results obtained.								
V 1639 (11) ..	1·64	1·99	4·05	350	—	2·794	21·60	Heat-treated.
V 1564 ..	1·48	1·90	3·90	350	—	2·784	21·00	"
The above two bars show density corresponding with a tensile strength of 21 tons per square inch.								
				3 : 1 *Mould.*				
V 1712 (4) ..	1·55	2·10	4·01	200	2·788	2·788	19·80	Heat-treated.
V 1706 (6) ..	1·45	1·95	3·84	200	2·790	2·790	23·38	"
V 1784 (5) ..	1·48	2·04	4·00	150	2·792	2·792	21·35	"
V 1784 (6) ..	1·48	2·04	4·00	140	2·792	2·792	21·82	"
V 1786 (5) ..	1·50	2·01	4·08	155	2·792	2·792	21·80	"
V 1787 (10) ..	1·54	1·99	3·91	145	2·794	2·793	20·80	"
				2 : 1 *Mould.*				
V 1750 (1) ..	1·60	1·98	3·99	150	—	2·786	—	—
V 1750 (2) ..	1·60	1·98	3·99	150	—	2·782	—	—
V 1750 (5) ..	1·60	1·98	3·99	150	—	2·786	—	—
V 1750 (6) ..	1·60	1·98	3·99	150	—	2·790	—	—
V 1750 (9) ..	1·60	1·98	3·99	150	—	2·790	—	—
V 1750 (10) ..	1·60	1·98	3·99	150	—	2·787	—	—

In the case of the test-pieces from the 3:1 mould the difference in density between roughed-out test piece and ¾ in. diameter rod is shown to be negligible.

* Engineering Standards test-piece C, diameter at shoulders ¾ in.

* Paper read at the meeting of the Institute of Metals, on Wednesday, March 7.

† The "Y" alloy contains copper 4 per cent., nickel 2 per cent., magnesium 1·5 per cent. See "Eleventh Report to the Alloys Research Committee of the Institution of Mechanical Engineers, 1921."

* Engineering Standards test-piece C, diameter at shoulders, ¾-in.

† Considerable attention has been given to the question of the effect of the mass of mould and the formation of radial crystals in the case of steel ingots.—J. E. Fletcher, ENGINEERING, vol. cvi, pp. 337 *et seq.*

diameter have a cross-sectional area of approximately seven times that of the chill-cast bar.

The effect upon the macrostructure of castings produced by variation of the mould temperature is indicated in Fig. 1, which shows a series of macrosections of 1 in. diameter chill-cast bars obtained by keeping other conditions as constant as possible while varying the mould temperature, rising in steps of 50 deg. C. from 150 deg. C. to 500 deg C. The effects obtained over this range of mould temperature show a core whose visible porosity diminishes with rising mould temperature up to 350 deg. C. The casting obtained with the mould at that temperature appears to be the most satisfactory of the series; with higher mould temperature the general

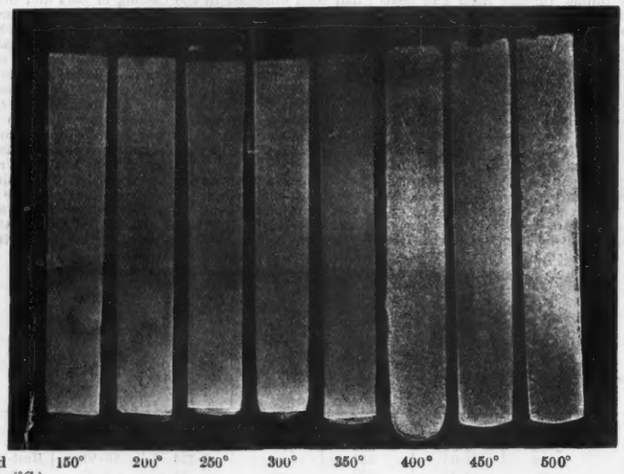


FIG. 1.

× ½. (REDUCED BY ONE-THIRD IN REPRODUCTION.)

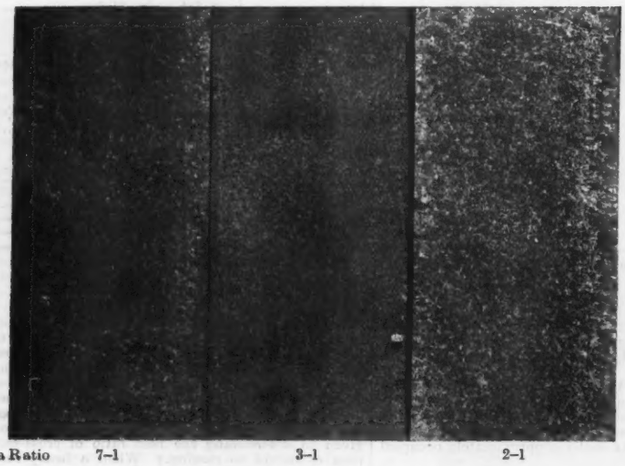


FIG. 2.

× 2. (REDUCED BY ONE-THIRD IN REPRODUCTION.)

retardation of cooling becomes too great, resulting in a coarse structure, which is generally accompanied by widely distributed minute unsoundness.

With a mould temperature of 350 deg. C., a pouring temperature of 750 deg. C. was found to give the best result. At lower pouring temperatures cold shutting developed, and above 750 deg. C. bars having a coarser grain were produced.

It will be seen from the above remarks and the photographs shown in Fig. 1 that, with the comparatively heavy iron moulds used in these experiments, the power of controlling the depth of chill is very limited, and there is the further disadvantage that a comparatively slight change in the method of manipulation makes very considerable difference to the result, so that the permissible variations in the working process are too small to be readily observed in practice. The aim has accordingly been kept in view by the authors to provide, if possible, a method of producing sound castings which should be easy of application, and this implies a reasonably wide latitude in regard to the various operating details.

New Moulds.—In order to obtain moulds with a diminished chilling effect, two lighter types having cross-sectional areas respectively three times and twice that of the cast bars were tried. The densities and macrosections of the resulting castings have been examined. These new cast-iron moulds had wall thicknesses of ½ in. and ¼ in. respectively. Batches of bars were cast in them, varying the mould temperature and casting temperature in order to determine the best condition for each type of mould. It was found that for the mould having a ratio of area of 3 : 1 the best temperature was 150 deg. C. to 200 deg. C., with a casting temperature of 750 deg. C.; used in this way moulds of this type gave excellent bars. Density determinations carried out on bars roughly machined to the shape of a test-piece are given in Table I, correlated in a number of instances with tensile tests.

In the case of bars cast in the moulds having a cross-sectional area ratio of 3 : 1, the density of the bars machined to ⅞ in. diameter is also given. It will be seen that the corresponding values are practically identical, showing that there is no appreciable central unsoundness.

The attainment of a uniformly high density throughout the cross-section of the rods is seen to be correlated with a uniformly high value of the ultimate stress under tensile test. So close is this correlation between a density of approximately 2·79 and a tensile strength exceeding 20 tons per square inch, that in further cases the density determination alone has been relied upon.

In order to illustrate the effect of varying mould cross-section upon the macrostructure of the resulting casting, portions of vertical sections of three typical cast bars are shown under a magnification of two diameters in Fig. 2. It will be seen that the mould having the 3 : 1 ratio gives the most desirable structure.

In Table I there is one bar, numbered 1706 (6), which shows a remarkable ultimate strength of 23·38 tons per square inch. The full results of the tensile tests on this bar (see Table III) were as follows:—

Yield stress	...	17·00 tons per square inch.
Maximum stress	...	23·38 tons per square inch.
Extension on 2 in.	...	14 per cent.
Reduction of area	...	15 per cent.

The microstructure of the bar is illustrated in Figs. 3, 4 and 5. Fig. 3 shows the general distribution of the constituents under a magnification of 150 diameters. It will be seen that the individual particles have a well-rounded form, and are arranged in a manner suggesting that the original cast network was exceptionally fine. Fig. 4 shows the crystal boundaries under a magnification of 300 diameters. It will be seen that the compound constituents tend to arrange themselves along the intercrystalline boundaries. Fig. 5 shows the intermetallic compounds present in this alloy under a magnification of 500 diameters. The most darkly etched body is the compound $NiAl_3$, while the lighter etched is a ternary body containing copper, aluminium and nickel. The presence of magnesium, or magnesium silicide, is not readily detected in these photomicrographs. While it might perhaps be hoped that chill-castings of the "Y" alloy could regularly be obtained having the remarkable

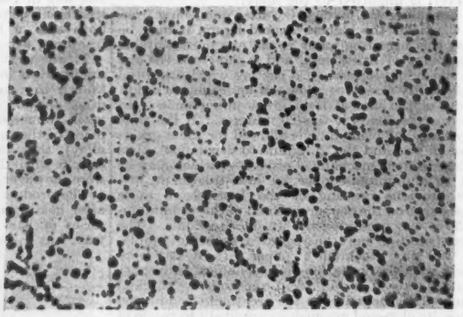


FIG. 3. HEAT-TREATED STRUCTURE OF 23·4-TON BAR.

× 150.

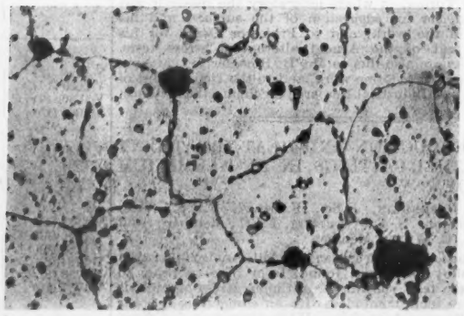


FIG. 4. HEAT-TREATED STRUCTURE OF 23·4-TON BAR.

× 300.

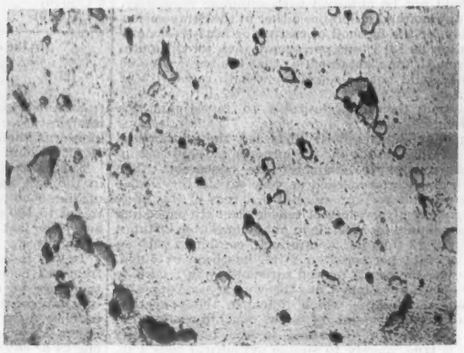


FIG. 5. HEAT-TREATED STRUCTURE OF 23·4-TON BAR.

× 500.

properties of this exceptional bar, it is probable that the conditions of heat-treatment required lie so close to the limit of safety that it would not be practicable to employ them regularly in industrial practice. The authors are therefore inclined to regard the results set out above, leading to a regular value of the ultimate stress in the neighbourhood of 20 tons per square inch to 21 tons per square inch, as satisfactory, particularly as the properties of the alloy in this condition are very good from the point of view of resistance to fatigue (see below).

Grain Size.—In the preparation of batches of castings for density determination, the very fine machined finish employed revealed the grain-size of the castings, and it was noticed that a considerable difference existed in the grain-size in spite of the fact that the conditions of casting had been regulated with the greatest care. The only variable was the rate of pouring, which could be controlled only by personal judgment. The various grain-sizes observed can conveniently be grouped as "A," coarse; "B," medium, and "C" fine. The structures observed are illustrated in Figs. 6, 7 and 8. Fig. 6 shows the machined surface of the castings, while the

corresponding densities are given on the figure. It will be seen that the finer structure corresponds with a higher density. Fig. 7 shows transverse sections and Fig. 8 vertical sections through the castings.

The variations of density and tensile strength as related to the three groups of grain-size are tabulated in Table II.

To test the effect of variations of pouring rate on grain-size a series of bars has been cast, keeping other conditions as constant as possible, while the time taken to fill the mould was carefully determined. Transverse sections of castings poured at five different rates are shown in Fig. 9 under a magnification of three diameters. An examination of these macrographs suggests that it is important to secure, if possible, an even closer control of the rate of pouring. In order to obtain the best results it is necessary to aim at filling a mould 7 in. long by 1 in. diameter in not less than 10 seconds; the slower the rate the better the result, provided that cold shuts can be avoided.

Heat-Treatment of the Castings—Blistering.—Broken blisters on the surfaces of cast bars which had been heat-treated in the salt bath at a temperature in the neighbourhood of 530 deg. C. have been observed in a number of cases, even where the castings had been made in the improved lighter moulds, and showed satisfactory density. This is particularly the case with a batch which was heat-treated for six hours at a temperature ranging between 534 deg. C. and 517 deg. C. Microscopic examination of a cross-section taken through one of these blisters appeared to indicate that superficial melting might have taken place, the molten salt penetrating into cavities left by the removal of liquid metal. The microscopic appearance of a cross-section of such a blister is shown in Fig. 10 at a magnification of 300 diameters. Since the blisters appeared to be merely superficial, the bars were tested in the usual way and gave the results shown in Table III.

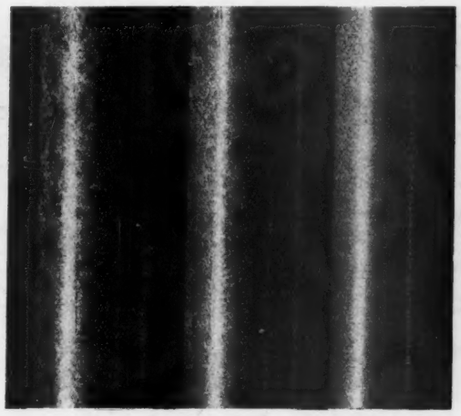
It will be seen that in general the results are good and consistent. Indeed, one of the bars is an exceptional one, to which reference has already been made.

This observation negatives the previously held idea that the discoloration of fractures referred to above might in some way be connected with the formation of blisters. The fact that there is no connection between these two phenomena has been further verified by a series of other tests.

In order to arrive at the conditions governing the formation of these blisters, various heat-treatment experiments were undertaken. In parallel sets of experiments it was found that heating above 525 deg. C. in the salt bath produced blisters, while in the electric muffle furnace a temperature of 545 deg. C. could be reached without blistering. The temperature 525 deg. C. must therefore be regarded as a limit for "Y" alloy castings when in contact with fused salt. This temperature is too low to allow the blistering to be explained by partial melting of the alloy, particularly as treatment in an electric muffle furnace at that temperature shows no signs of any such action. It would seem probable, therefore, that chemical action between the fused salt (nitrates) and the alloy plays a part in the production of the blisters, possibly by causing a local rise in temperature.

The presence of magnesium appears to affect this phenomenon fundamentally, since it was found that an alloy containing copper 4 per cent., nickel 2 per cent., aluminium remainder, could be heated to 550 deg. C. in the salt bath without blistering. The further investigation of the phenomenon was accordingly abandoned and, for the time being, the use of the electric muffle furnace was adopted for the purpose of obtaining the highest possible results with the "Y" alloy. In order to secure a uniformity of temperature of the castings while undergoing heating in the muffle, they were enclosed in a box made of sheet iron and lined internally with a

DENSITY:
"A" 2·772
"B" 2·783
"C" 2·790

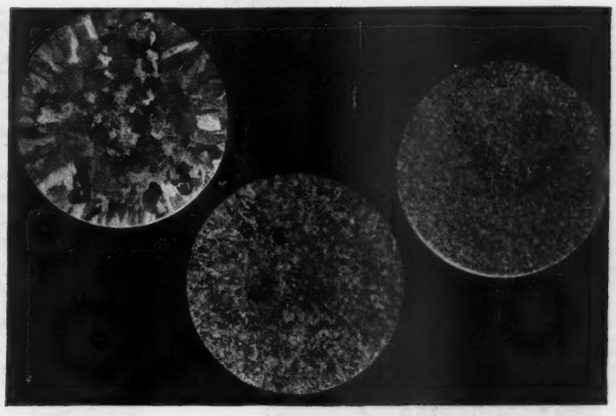


Grain "A" "B" "C"

FIG. 6.

× 1½. (REDUCED BY ONE-THIRD IN REPRODUCTION.)]

"A" "C"



"B"

FIG. 7.

× 4. (REDUCED BY ONE-THIRD IN REPRODUCTION.)

"A" "B" "C"

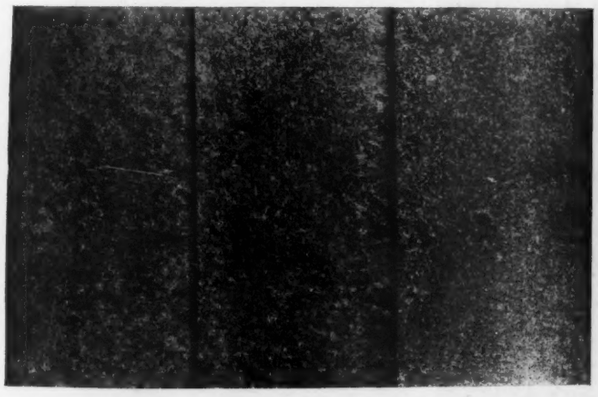
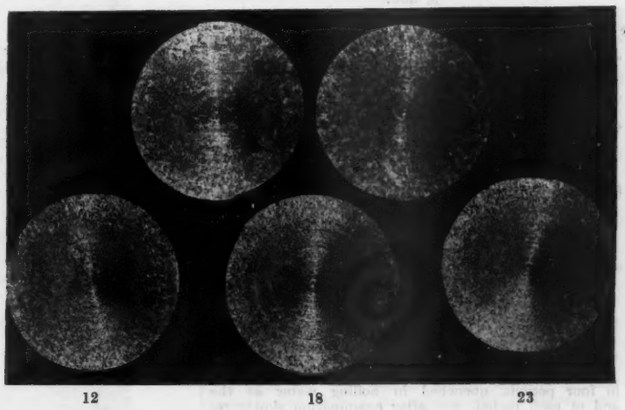


FIG. 8.

× 2. (REDUCED BY ONE-THIRD IN REPRODUCTION.)

TIME IN SECONDS: 3 7



12 18 23

FIG. 9.

× 3. (REDUCED BY ONE-THIRD IN REPRODUCTION.)

TABLE II.

Grain-Size.	Corrected Density. Grms. per c.c. (Rough machined test-piece)	Ultimate Stress. Tons per Sq. Inch. (As cast)	Remarks.
(*a*) Coarse ..	2·772	9·60	Illustrated in Figs. 6, 7 and 8.
(*b*) Medium ..	2·783	10·93	
(*c*) Fine ..	2·790	12·58	

TABLE III.

Melt No.	Corrected Density. Grms. per c.c. (Roughed-out test-piece, heat-treated)	Yield Stress. Tons per Sq. In.	Ultimate Stress. Tons per Sq. In.	Elongation per Cent. on 2 In.
V 1706 (6) ..	2·789	17·00	23·38	14
V 1712 (3) ..	2·781	15·38	18·53	4
V 1712 (8) ..	2·781	15·65	18·08	4
V 1706 (5) ..	2·777	14·54	18·48	5
V 1712 (7) ..	2·777	14·29	19·47	6

TABLE IV.

Melt No.	Corrected Density. Grms. per c.c. (Test-pieces machined to approximate dimensions.)	Grain Class.	Yield Stress. Tons per Sq. In.	Ultimate Stress. Tons per Sq. In.	Elongation per Cent. on 2 In.
V 1784 (4)	2·791	(*c*)	16·36	20·62	5
V 1784 (5)	2·792	(*c*)	16·36	21·55	6*
V 1784 (6)	2·792	(*c*)	15·79	21·82	6

* Broke outside gauge marks.

thickness of asbestos of ¼ in. This arrangement proved perfectly satisfactory and gave uniform results.

In each of several batches of bars, the heat-treatment was carried out in periods with intermediate quenching and reheating, accompanied by a microscopic examination of the structure of the bars. If this was not found satisfactory, the bars were not allowed to age, but were slowly reheated to the temperature of treatment. Some of the results obtained are indicated in Table IV.

The corrected density of the roughly machined test-piece in grms. per cubic centimetre is given, together with the yield stress, ultimate stress and elongation. The total time of heating at temperatures between 520 deg. C. and 530 deg. C. was five hours. The bars were afterwards quenched in boiling water and allowed to age for eight days before testing.

Six further typical results are tabulated in Table V.

The chemical analyses of the three heats from which these bars have been selected are given in Table VI.

TABLE VI.

	V 1784.	V 1786.	V 1787.
	Per Cent.	Per Cent.	Per Cent.
Magnesium ..	1·48	1·50	1·54
Nickel ..	2·04	2·01	1·99
Copper ..	4·00	4·08	3·91

It will be seen that the compositions approach very closely to the nominal values of 4 : 2 : 1¼. It may be mentioned that in each of these cases the alloy has been remelted. It is an incidental observation from the present research that remelting, so far from being disadvantageous to this alloy is, if properly conducted, distinctly advantageous. Consistently superior results have been obtained from castings made from remelted alloy.

The changes in microstructure which occur during the heating process are illustrated by the photomicrographs Figs. 11 to 14 inclusive. Fig. 11 shows the microstructure of the casting at a magnification of 300 diameters, the section being unetched, as the network constituent is plainly apparent even in that condition. After a first heating period of approximately two hours at 520 deg. C. the microstructure has changed to that illustrated in Fig. 12 under the same magnification as before. It will be seen that the thick and continuous network of Fig. 11 has begun to disappear and to break up in places. This change is more markedly visible in Fig. 13, which represents the structure of the alloy as seen under the same magnification as before, at the end of the second period of heat-treatment (five hours in all). The final stage reached at the end of the heat-treatment (10 hours in all), and regarded as satisfactory for this purpose, is shown in Fig. 14 at the same magnification. It will be seen that here the network structure is only faintly traceable, and that the intermetallic compounds present in the alloy have to a large extent become balled up. It will thus be seen that the heat-treatment process applied to this alloy bears some small resemblance to the malleableizing process applied to cast iron. It must be borne in mind, however, that there are changes in this alloy which are not revealed by an examination of the microstructure. A part of the purpose of heat-treatment is to bring into solid solution constituents which in the condition of the alloy as cast exist as separate constituents. Similarly, the changes which occur during ageing and hardening are not readily seen under the microscope, although their nature has been fairly fully elucidated.

Fatigue Range (Alternating Stress Tests).—The remarkably high and consistent values obtained in tensile tests on heat-treated chill-cast bars, prepared in the manner described above, made it of interest to ascertain the resistance of such treated castings to fatigue, particularly in view of the possibility of the employment of such material for moving parts of machinery. Determinations of the fatigue range have therefore been carried out in the engineering department of the laboratory by Mr. H. Gough.

(*a*) *Hollow Test-pieces.*—Tests of the Wöhler type on hollow test-pieces were carried out by means of the strain-load method. These indicated the limit of proportionality at a value of ± 5·8 tons per square inch. The tests, however, on the hollow test-pieces were somewhat unsatisfactory and inconsistent, as several test-pieces broke at points away from the region of maximum stress. Such results are not surprising, in view of the fact that the shape of the curve obtained in the determination of the limit of proportionality was of the kind which would be expected from a material not completely homogeneous, or containing slight flaws. In such cases the use of hollow specimens gives unduly low values.

(*b*) *Solid Test-pieces.*—Solid test-pieces used in a similar manner gave perfectly consistent results, which are given in Table VII.

It will be observed from this table that a series of

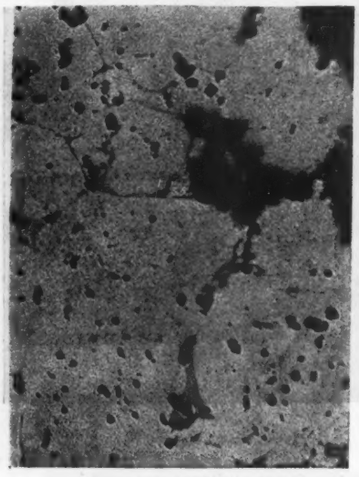


FIG. 10.

BLISTERED AREA, HEAT-TREATED BAR.
× 300.

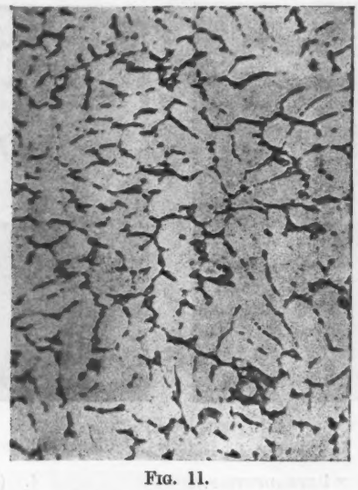


FIG. 11.

CAST ROD BEFORE HEAT TREATMENT.
× 300.

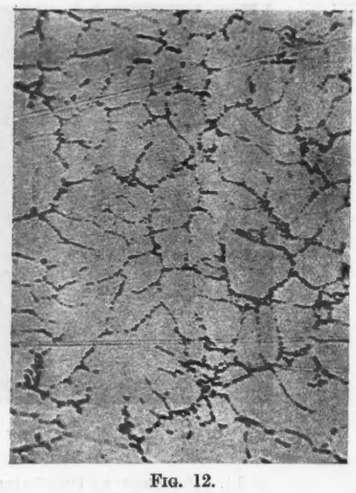


FIG. 12.

AFTER 2 HRS. AT 520° C.; QUENCHED.
× 300.

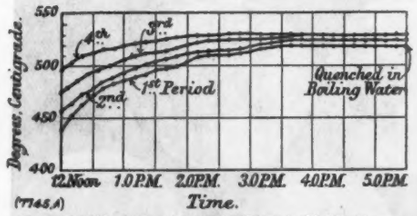


FIG. 15.—Heat-Treatment in Electric Muffle Furnace of Bars included in Table V., contained in Special Box. Charged into muffle furnace—

1st period	9.30 a.m., 14.9.22.
2nd period	9.50 a.m., 15.9.22.
3rd period	9.25 a.m., 18.9.22.
4th period	9.15 a.m., 20.9.22.

The bars represented in Table V were heat-treated in four periods, quenched in boiling water at the end of each period, and after examination slowly reheated on each occasion and retained for a total period of 10 hours at temperatures between 520 deg. C. and 530 deg. C. They were again allowed to age for eight days after final quenching.

TABLE V.

Melt No.	Corrected Density. Grms. per c.c. Roughed-out Test Pieces.	Grain Class.	Time to fill Mould. Seconds.	Yield Stress. Tons per Sq. In.	Ultimate Stress. Tons per Sq. In.	Elongation per Cent. on 2 In.
V 1786 (1)	2·791	(c)	12	16·76	20·31	5*
V 1786 (2)	2·790	(c)	10	16·40	19·53	5
V 1786 (4)	2·794	(c)	10	16·44	20·07	5*
V 1786 (5)	2·792	(c)	10	16·80	21·20	7
V 1786 (6)	2·795	(c)	10	16·36	20·42	5
V 1787 (10)	2·793	(c)	16	16·36	20·78	7

* Broke outside gauge marks.

Furnace temperatures recorded during the heat-treatment of the bars in Table V are shown in the graphs of Fig. 15.

The figures quoted in Tables IV and V are merely examples and represent pieces taken at random from three different heats.

FIG. 13.

AFTER 5 HRS. AT 520° C.; QUENCHED. × 300.

FIG. 14.

AFTER 10 HRS. AT 520° C.; QUENCHED. × 300.

gradually increasing loads was applied to seven specimens. After the required number of reversals had been endured for each individual test-piece, the load was increased and a further test made on the same specimen. The results clearly indicate that the fatigue range of the alloy is raised by preliminary understressing in the manner described.

TABLE VII.

Melt No.	Maximum applied Stress. Tons per Sq. In.	Reversals.	Remarks.
1787 (9)	± 5·7	19,066,400	Unbroken.
	± 7·9	990,100	Broken at point where maximum stress = ±7·2 tons per square inch.
1790 (4)	± 6·1	19,275,900	Unbroken.
	± 7·4	13,623,000	,,
	± 8·2	9,690,000	,,
	± 9·5	3,404,100	,,
	±11·6	24,510	Broken.
1790 (5)	± 7·2	1,185,700	,,
1790 (7)	± 6·9	13,930,000	Unbroken.
	± 7·8	10,735,000	,,
	± 9·0	1,504,800	Broken.
1790 (12)	± 7·8	8,390,200	Broken at point where maximum stress = ±7·5 tons per square inch.
1790 (16)	± 7·0	12,409,700	Unbroken.
	± 9·2	876,000	Broken at point where maximum stress = ±8·4 tons per square inch.
1790 (20)	± 9·1	1,419,000	Broken.

Taking the results from the initial loads in each case, and therefore eliminating the advantage from preliminary understressing, the figures are as given in Table VIII.

TABLE VIII.

Melt No.	Range of Stress Tons per Square Inch.	Alternations Endured.	Remarks.
1787 (9) ..	±5·7	19 × 10⁶	Unbroken.
1790 (4) ..	±6·1	19 × 10⁶	,,
1790 (7) ..	±6·9	14 × 10⁶	,,
1790 (16) ..	±7·0	12 × 10⁶	,,
1790 (5) ..	±7·2	1·2 × 10⁶	Broken.
1790 (12) ..	±7·8	8·4 × 10⁶	,,
1790 (20) ..	±9·1	1·4 × 10⁶	,,

The results given in the above table indicate that the material has a safe range under alternating stresses of approximately ± 7 tons per square inch. This is a remarkable value, since it is considerably higher than any which have yet been recorded for light aluminium alloy castings, and is not very much below the value for the best wrought aluminium alloys which show a range of the order of ± 10 tons. These results suggest the possibility that this alloy is in the form of heat-treated chill-castings may be used with advantage in cases where fatigue stresses are of importance.

Other Experiments.—The use of graphite moulds having been developed in the laboratory in connection with work on other alloys, those moulds were tried for the production of "Y" alloy cast bars. The result was quite successful, but the bars produced are not in any way superior to those obtained from the light type of cast-iron mould having the 3 : 1 ratio of cross-sectional area.

Since the bars produced in graphite moulds, although equal, are not superior in quality to those produced in the cast-iron moulds, there would appear to be no advantage in the use of the former.

Mould Dressings.—One of the advantages of the graphite moulds, not so readily obtainable in iron moulds, is the high quality of surface which can be obtained in the resulting castings. In order to lessen the tendency towards cold shutting when very slow rates of pouring are employed, various mould dressings have been used. A thick paste made by mixing "00 superfine" plumbago with some fairly thick lubricating oil has proved very effective. This paste is applied with a brush, only a thin film being necessary, and is then smoothed over with the finger.

Summary.—1. The variable and inferior results which have sometimes been obtained have been definitely connected with unsoundness in the chill-cast rods, and it has been shown that they are not due to any of the subsequent operations, including heat-treatment. A study of the density of chill-cast bars has shown that this varies from 2·74 to 2·79, and that there may be marked variations in the density of the single bar from the exterior to the core. Correlation of macrostructure with density has shown that such a density gradient is associated with a marked difference in character of structure between the core and the outer portions of the casing, and that this is due to the formation of too deep a ring of so-called chill crystals radiating inwards from the surface of contact with the mould. Such a structure arises from too severe a degree of chilling of the molten metal by the mould, and this is found to result from the employment of chill moulds of too great a thickness of wall.

By a proper proportioning of the cross-sectional area of the mould to the cross-sectional area of the casting, and careful control of casting conditions, it has been found possible to eliminate marked difference in density between exterior and interior of the cast chill rods, and to bring the density even of the central core of the cast rod to a value closely approaching that of the alloy in the wrought condition (2·80).

This result has an important bearing on die-casting generally, in metal moulds, in connection with the production of castings of maximum soundness and strength.

The conditions which have been found to give the best results are as follows :—

(*a*) The ratio of cross-sectional area of mould (grey cast iron) to that of the casting to be 3 : 1.

(*b*) The mould, dressed with a thick paste of plumbago and lubricating oil applied in a thin film, to be heated to 150° C. to 200° C. and used tilted to an angle of 30 deg. to the vertical.

(*c*) The temperature of the alloy in the crucible during melting not to exceed 800° C.

(*d*) The molten alloy to be poured at 750° C. in a slow stream, striking the mould as near the top as possible to avoid the danger of a "hot spot."

(*e*) The time taken to fill the mould 7 in. by 1 in. diameter to be not less than 10 seconds.

Rods cast in accordance with the above conditions show tensile strength in the neighbourhood of 20 tons per square inch and from 5 per cent. to 6 per cent. extension on 2 in. If their density is satisfactory, such results can be regularly relied upon after proper heat-treatment.

In the case of one particular rod, which in the form of a roughed-out test-piece was found to have a density of 2·789, the following remarkable tensile test results were obtained after heat-treatment :—

Yield stress ...	...	17·00 tons per square inch.
Maximum stress	...	23·38 ,, ,,
Extension on 2 in.	...	14 per cent.
Reduction of area	...	15 per cent.

2. No change in density has been observed to result from heat-treatment.

3. No advantage has been obtained in the case of this alloy by the employment of graphite moulds in place of cast-iron ones.

4. The resistance to alternating stresses (fatigue range) of these alloys has been determined, and it has been found that cast heat-treated rod prepared as described in the present paper will withstand twelve million reversals of a maximum fibre stress of 7·0 tons per square inch. The test results indicate a safe fatigue range of ± 7·1 tons per square inch. This result is considerably superior to any values which have hitherto been obtained from cast aluminium alloys.

Heat-treatment.—1. The use of temperatures exceeding 525° C. during heat-treatment in a salt bath has been found to cause blisters to form on the surfaces of castings. Excellent results have, however, been obtained from tensile tests of test-pieces machined from blistered rods.

2. At a temperature of 520° ± 5° C., six hours is a sufficiently long period of heating.

3. The plunging of the cast rods at normal temperature directly into the salt bath at 520° C. has been found to be perfectly safe and free from danger of causing cracking. Similar remarks apply to the quenching operation after heating at 520° C. in boiling water.

In conclusion, the authors wish to thank their colleagues, Mr. P. G. Ward, B.Sc., and Miss O'Hea for numerous chemical analyses carried out.

The work described in the present paper is part of an investigation of aluminium alloys now being carried out at the National Physical Laboratory under the auspices of the Materials and Chemistry Sub-Committee (Light Alloys Panel) of the Aeronautical Research Committee, and under the Engineering Co-ordinating Research Board of the Department of Scientific and Industrial Research. The authors desire to express their thanks to these bodies for permission to publish this paper.

EQUIPMENT FOR GRAIN ELEVATORS, CANADA.—While on a recent visit to Port Arthur and Fort William, His Majesty's Trade Commissioner at Winnipeg ascertained that large extensions to existing grain storage elevators there will be undertaken during the present year. Further information in this matter can be obtained from the Department of Overseas Trade, 35, Old Queen-street, S.W. 1.

THE LATE MR. AMBROSE EDMUND BUTLER.—It is with the greatest regret that we announce the severance of a tie of the family of Butler with the industrial prosperity of Leeds. The chairman of the Kirkstall Forge, Limited, Mr. Ambrose Edmund Butler died at the age of 75, on Saturday, February 24. He had been in failing health for some time, but his condition became more serious after the death of his wife last October. He was a representative of the fourth generation of his family associated with the business and with his two brothers, Mr. B. Fawcett Butler and Hugh M. Butler, M.P., he controlled and developed its activities while maintaining its traditions. Public affairs were not neglected by him and he rendered faithful service to his fellow citizens as Lord Mayor of Leeds.

THE RAILWAYS OF JAPAN.—The annual statistical statement regarding the working of the railways of Japan show that a considerable improvement in operation has been brought about in recent years to offset the increase in working expenses. Thus compared with 1916–17 when the goods-wagon receipts per train mile amounted to 2·14 yen (the yen is normally 2*s.*), in 1920–21 the corresponding figure was 3·83 yen. The number of passenger vehicles per train has been increased from 12·3 to 13·7 and of goods vehicles from 28·1 to 38·9. The number of vehicles drawn per locomotive has been increased from an average of 16·8 to 21·57. The tons per train-mile have been raised from 128 to 170·4, though the tons per vehicle mile have scarcely altered. The total capital amounted to 1,542,381,275 yen, on which a return of between 7 per cent. and 8 per cent. has been maintained for a number of years.

CATALOGUES.

Thermometers.—A post card illustrating an index thermometer and a thermograph is to hand from the Cambridge and Paul Instrument Company, Limited, 45, Grosvenor-place, London, S.W. 1.

Heat-Treatment Furnaces.—A list of Wild-Barfield electric furnaces giving particulars of sizes, output and cost of current has been received from Automatic and Electric Furnaces, Limited, 173, Farringdon-road, London, E.C. 1.

Lightning Arresters and Motor Starters.—Two excellent explanatory catalogues dealing with horn gap lightning arresters, and auto-transformers and star-delta starters for induction motors are to hand from the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester.

Deck Machinery.—A catalogue of ships' electric cranes, winches, warps, service and baggage hoists and jib cranes has come to hand from Messrs. Chambers, Scott and Co., Limited, Motherwell, who have supplied machinery of this class for many of the largest passenger and cargo vessels.

Boiler Fittings.—Valves, pipe connections, gauges, lubricators and similar fittings for engines, boilers and hot-water apparatus, in gun-metal and cast-iron, are dealt with in a catalogue issued by Messrs. Smith Brothers and Co. (Hyson), Limited, Nottingham. Lists of dimensions and prices are included.

Presses.—A series of power presses in the various forms used for sheet-metal working, &c., and made in sizes capable of exerting pressures of 5 tons, 12½ tons, 25 tons, 40 tons and 60 tons, is illustrated in a catalogue received from Messrs. Arnold and Large, Limited, 53, Broad-street, Birmingham.

Oil Coolers.—The apparatus for cooling the oil in lubricating systems, electric transformers, quenching tanks, &c., made by the Serck Radiators, Limited, Warwick-road, Greet, Birmingham, is very clearly described with some useful technical information in a new catalogue issued by the firm.

Marine Turbines.—Messrs. Brown, Boveri and Co. Limited, Baden, Switzerland (London: Trafalgar House, Waterloo-place, S.W. 1), have sent us a 32-page illustrated booklet giving an interesting account of the development and present construction of the marine steam turbine for both naval and mercantile service.

Tipping Trucks.—Circulars illustrating trailer trucks for road service, with tipping bodies discharging at either side or at the rear end, and also two types of end-tipping bodies for fitting to Ford 1-ton motor trucks, have come to hand from Messrs. Alexander Laurie and Sons, Falkirk. In all cases a full specification of construction is given.

Electric Light Fittings.—A handsome catalogue, of about 250 pages quarto, bound, containing illustrations, prices and other particulars of pendants, brackets, standards and other fittings for electric lighting has been issued by the General Electric Company, Limited, Kingsway, London, W.C. 2. Many of these fittings are of highly artistic designs.

Boiler Feed System.—The closed circuit feed-water system of Messrs. Hicks, Hargreaves and Co., Limited, Bolton, was mentioned recently in these notes (see page 59 *ante*) and we have since received a more fully descriptive catalogue with diagrams of the piping arrangements, &c., for various applications. Considerable advantage is claimed in reducing the corrosion of boilers, tubes, &c.

Steel Tubes, &c.—A catalogue of cold-drawn steel pipes, from ¼ in. to 24 in. bore, storage cylinders for gases and air, and similar products, has reached us from the Chesterfield Tube Company, Limited, Chesterfield. The tubes, &c., are intended for high pressures and are made to comply with the requirements of Government departments, Lloyd's Register, the Bureau Veritas and similar authorities.

Boilers.—The Kirke patent fire tube boiler, made by Messrs. Spencer-Bonecourt, Limited, Hitchen, Herts. (Parliament Mansions, Victoria-street, London, S.W.), is constructed for rapid steam raising with forced draught; economy in working and low capital cost are claimed. The catalogue gives a clearly-worded and illustrated explanation which may be read with advantage by all interested in steam production.

Ball Joints for Pipes.—A catalogue of ball joints for pipes conveying gas, steam, water, compressed air, &c., comes from Messrs. Gwynnes Engineering Company, Limited, Hammersmith, London, W. A straight form of joint which has flange connections permits an angular movement of 18 deg. in any direction and is made in a full range of sizes for pipe diameters of 2 in. to 12 in. Smaller sizes are made with screwed connections, and these are supplied either straight or in various elbow patterns.

Electric Motors.—A catalogue giving prices and full particulars of small electric motors has been received from Messrs. A. C. Alexandra and Co., Limited, 10, Iddesleigh House, Caxton-street, Westminster, London, S.W. 1. The motors listed, which are made by Messrs. Howells and Co., of Hanley, Staffs., include a close range of sizes from the smallest up to 60 h.p., for single-phase and polyphase circuits, as well as a few small direct-current machines. Examples of motor generators, grinding and buffing motors, electrically-operated syrens and motors with reduction gearing, are illustrated.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

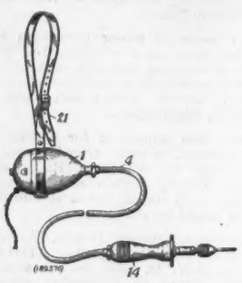
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

189,576. F. Pooley, Westminster, F. C. Austin, Westminster, and W. L. Wreford, Westminster. Portable Electrically-Driven Combination Tools. (3 *Figs.*) September 14, 1921.—The invention relates to portable electrically-driven combination tools of the kind in which an electric motor is employed to drive a tool through a flexible shaft. According to the invention, a portable electrically-driven combination tool



of the kind referred to, is arranged for the motor 1 to be carried on the person, by, for example, a harness or belt 21. A handle 14 and a shaft driven from the flexible shaft 4 and mounted so as to rotate therein, are arranged for the mounting or securing thereon of various attachments. Preferably, the electric motor 1 is totally enclosed in a casing, for example, of egg shape, so that it may be carried on the person without danger. (*Sealed.*)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

190,214. A. H. S. MacCallum, Caversham. Ignition Testing Means. (8 *Figs.*) September 10, 1921.—The invention relates to means for testing ignition of internal-combustion engines of the type wherein an indicator, such as a spark gap or vacuum tube, is connected in series with the sparking plug. According to the invention, the arrangement comprises an inductance connected in series with the spark-producing apparatus and the electric generator and an indicator connected in parallel with the inductance. The inductance and the indicator may form a complete unit to be mounted directly on a sparking plug. A

Fig.1.

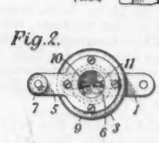


Fig.2.

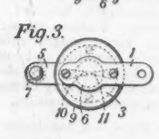
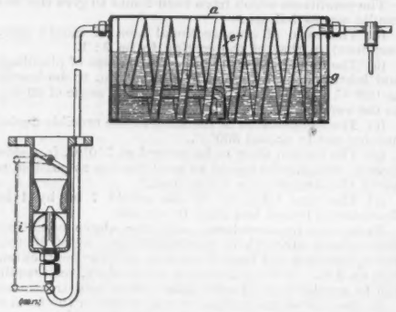


Fig.3.

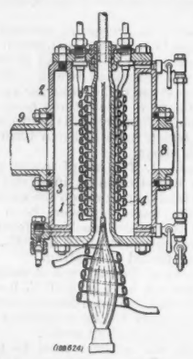
hollow cylindrical block of insulating material 3 has at its lower part a metal terminal member 1 of plate form, and on the upper part a second metal terminal member 5 of circular plate form having a circular central hole 6 and a terminal 7 mounted on a projecting portion thereof. A coil 9 is wound on the block 3 and is connected at its ends to the members 1, 5. Electrically connected to the member 1 is a bent metal member 10 and electrically connected to the member 5 is a bent metal member 11, the members 10, 11 being within the central hole 6 of the block 3 and so shaped and arranged that their ends are in close proximity. (*Accepted December* 29, 1922.)

189,173. W. Pickard, Rochdale. Internal-Combustion Engines. (2 *Figs.*) July 22, 1921.—The invention relates to the vaporisation or gasification of fuel for internal-combustion engines by apparatus in which the exhaust gases coming from the engine are employed for the vaporisation of the fuel supply. According to the invention, hydrocarbon liquid is fed to a container *a*, together with a quantity of water, in layers, the hydrocarbon settling out in a layer on top of the water. The container is heated by exhaust gases which are led through a worm *e* and are discharged therefrom into the receptacle *a* below the level of the water, which is driven off in the form of a saturated vapour and led to a nozzle *i* located in the usual valve-controlled induction pipe or fitting attached thereto. A layer or layers of gauze *g* is provided, below which the exhaust gas is admitted



and the hydrocarbon and water are admitted to the receptacle through float-controlled conduits so as to maintain a predetermined level of each. (*Sealed.*)

189,624. A. G. Mumford, Limited, Colchester, and A. W. Boothroyd, Lexden. Internal-Combustion Engines. (1 *Fig.*) October 25, 1921.—The invention relates to devices for heating heavy oil when used for power purposes in internal-combustion engines of the type in which the oil is passed through a range of piping located in a hot water chamber heated by the exhaust gases from the engine. A heater comprises a chamber 1 adapted to operate as a boiler, a jacket 2 surrounding



the chamber 1 provided with an inlet 8 and an outlet 9 for the exhaust gases from the engine, an open ended tube 3 passing longitudinally through the boiler chamber, the tube being carried by one of the end covers of the boiler chamber and passing through a gland on the cover of the other end of the boiler chamber, and a fuel pipe 4 passing through the boiler chamber, the part of the pipe within the chamber being coiled or otherwise shaped to give it a maximum heating surface. (*Accepted December* 13, 1922.)

HYDRAULIC MACHINERY.

189,287. Ransomes and Rapier, Limited, Ipswich, and Sir F. W. S. Stokes, K.B.E., Westminster, London. Sluice Gates. (4 *Figs.*) September 29, 1921.—The invention relates to sluice gates designed to regulate the flow in rivers subject to flood. The sluice gate according to the invention is so heavily counterweighted that it normally tends to open, and is provided with an automatic braking and releasing device normally preventing the gate from opening, but so controlled by a float L or a partially-immersed weight that the gate will be left free to

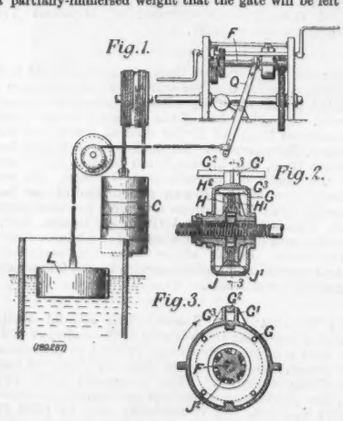


Fig.1.

Fig.2.

Fig.3.

open to a certain extent as the float L or weight rises. The float L or weight is placed in a chamber communicating with the stream above the sluice, and as it rises acts on the braking and releasing device, preferably through a lever Q, in such a manner as to leave the gate free to open under the action of the counterweight C to an extent depending on the amount of rise of the float L or weight. The braking and releasing device may be of any suitable form, but is preferably of the plate disc type mounted on a screw-threaded shaft which forms part of the ordinary hand or power-driven mechanism for closing the gate. The braking and releasing device is contained in a casing G, which carries a projection G^1 sliding on a fixed rod G^2 mounted parallel with the screw-threaded shaft F, so that the casing G cannot rotate with this shaft. The device consists of a plate disc brake containing two sets of discs. The discs H, H^1, H^2 of one set are slotted to engage internal projections G^3 on the casing G, and are therefore prevented from rotating with the shaft F. The disc H^1 of this set is provided with an internally screw-threaded boss, which engages with the screw-thread on the shaft F, so that rotation of the shaft causes the whole casing G to be traversed along it. The disc H is similarly provided with a boss, but this boss is formed as a sleeve to slide over the screw threads on the shaft. The other set of discs J, J^1 is mounted through a free wheel drive on a sleeve J^2 which has a projection riding in a horizontal slot in the shaft F, so that the sleeve J^2 always rotates with this shaft. The arrangement is such that when the shaft F is rotating in the direction of the arrow (Fig. 3), that is in the direction for opening the gate, the discs J, J^1 are locked to the sleeve J^2 forcing them to rotate with the shaft, while when the shaft F is rotating in the reverse direction to close the gate the discs are left free. (*Sealed.*)

LIFTING AND HAULING APPLIANCES.

190,517. The Underfeed Stoker Company, Limited, London, and E. W. Robey, London. Conveyors. (10 *Figs.*) August 24, 1921.—The invention relates to a method of causing a material to travel through a liquid. The liquid is confined in a trough which travels and conveys the material while the liquid as a whole remains stationary in the trough. The conveyor consists of short, dished troughs *a* which are connected together by india-rubber gussets *b*. Bosses on each side of the trough are drilled to receive watertight bolts *f* (Fig. 2), by which the links *g* of the conveyor chain are fixed to the trough. The links are pivoted to each other by bolts *h*, extensions of which form axles for wheels *i*. The wheels *i* run on upper and lower tracks *k*, k^1 beneath the ash pits *l* (Fig. 1), the chutes *l* of which extend into the conveyor formed by the connected troughs. The upper track *k* is curved upwards at one end and then assumes a straight path, being carried on an inclined girder k^2 to a height convenient for dumping the clinker and ashes. Here the links of the endless chain are engaged by a pair of positively-driven

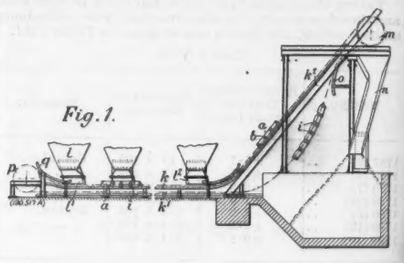


Fig.1.

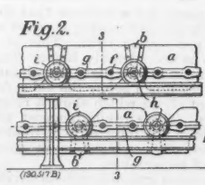


Fig.2.

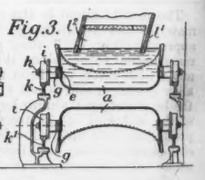
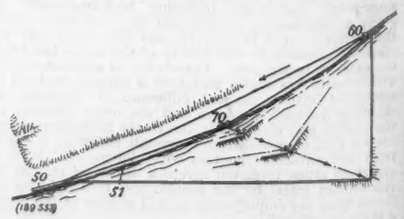


Fig.3.

sprocket wheels *m*. During their travel over the wheels *m* the troughs dump their contents into a chute *n* and the wheels *i* engage a short, curved track *o* by which they are guided into position for engaging the lower track k^1 when they arrive there. At the other end of the conveyor the chain links engage sprocket wheels *p* similar to wheels *m*, and are guided back to the upper track by guide rails *q*. As indicated in Figs. 1 and 3, the mouths of the chutes *l* are sealed by water in the conveyor, which water is retained owing to the upward curvature of the path of the conveyor at the ends of that portion of the path which is beneath the ash pits. The chutes *l* are provided with substantially air tight doors l^2 which can be opened by any abnormally large piece of clinker and can subsequently close automatically, in known manner. The troughs are dished in order that the clinker and ashes may be retained in the part of the conveyor which is travelling up the incline k^2. The angle at the rear end of the dishing of the trough is shallower than at the forward end to favour drainage of water from the material conveyed (*Accepted December* 30, 1922.)

MINING, METALLURGY AND METAL WORKING.

189,553. H. F. H. Shields, Welling, Kent, and The British Ropeway Engineering Company, Limited, London. Distributing or Dumping Material. (8 *Figs.*) September 2, 1921.—The invention relates to distributing or dumping material, particularly for reclaiming land by dumping material thereon. According to the invention, there is provided a method of distributing or dumping material consisting in erecting between



two fixed terminal stations 50 60. situated adjacent to the area to be reclaimed, an aerial ropeway comprising an "out-going line" 51 carried over a part of the area by movable supports 70 that overhang the same. The material from containers suspended from the "out-going line is dumped," and the movable supports 70 are progressively advanced to the margin of the dumped material in a direction transverse to the line joining the terminal stations 50, 60. (*Accepted December* 13, 1922.)